COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

August, 1945

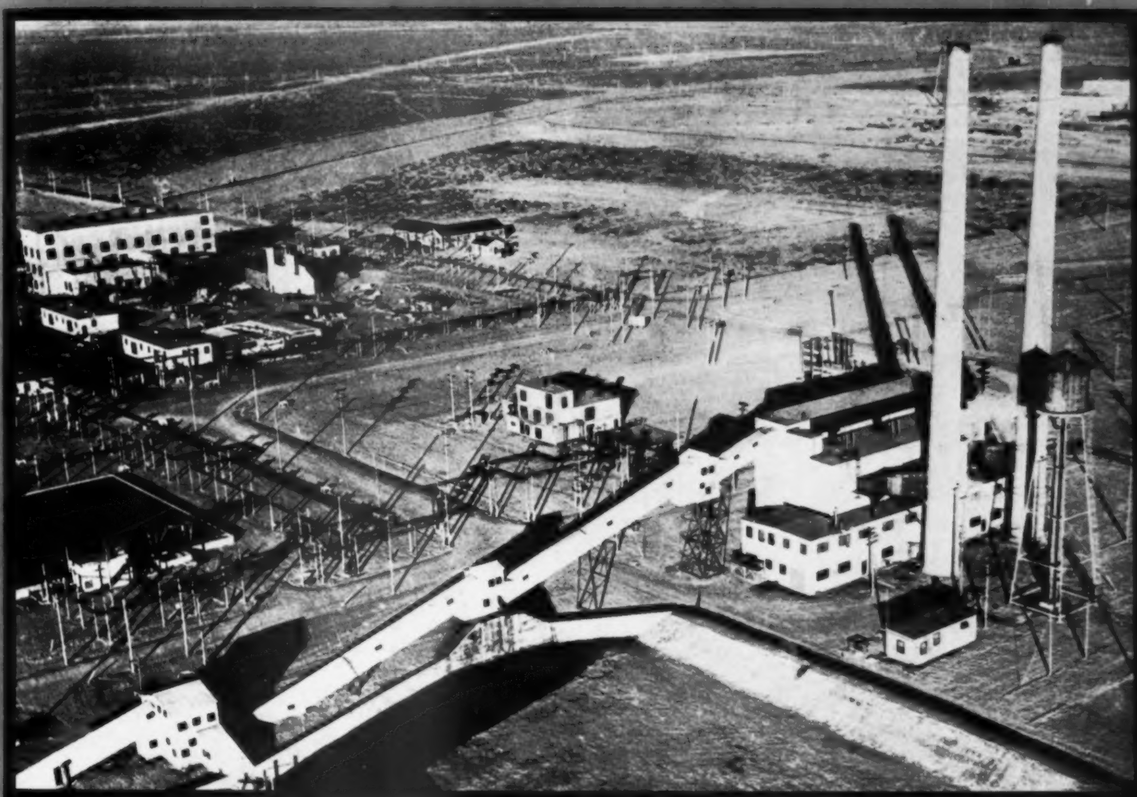

Photo by ACME

One of several steam plants serving the production of "atomic bombs"

Expansion Problems Encountered in the Design of Steam Generating Plants ▶

Starting Pulverized-Coal-Fired Boilers ▶

Increase in Industrial Power, 1939-1945 ▶

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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ALFRED D. BLAKE, *Editor*

THOMAS E. HANLEY, *Circulation Manager*

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Editorial

Smoke

An effect of the war in some communities has been a noticeable increase in smoke. This may be attributable to several factors, including increased industrial activity, the overloading of more or less obsolete equipment, in some cases lack of experienced operators, the forced use of fuel poorly adapted to the firing equipment, manpower shortage among enforcement bodies, and perhaps to some extent, a feeling that the public should not be too fussy about such matters under the stress of winning the war. Moreover, in many residential sections during the heating season, the necessity of burning substitute fuels has tended toward atmospheric pollution as is attested by the appearance of newly painted houses.

It is anticipated that the post-war period will see a revival of the demand for cleaner atmospheres. However, the problem may be rendered more difficult by the limited supply of low-volatile coals available to many communities and the possibility that use of oil and gas may become more restricted. Offsetting these factors is the steady improvement that has been going on in the design of fuel-burning equipment, the more extensive application of overfire air, and the probable availability of experienced operators. Also, if backed by public opinion, it should be possible for the enforcement agencies to build up their staffs to resume the educational work interrupted by the war. The progress already made must not be permitted to retrograde.

Looking Forward

Commenting upon a recently announced long-range plan calling for unified effort by electric power companies and equipment manufacturers to accelerate the further use of electric energy by American industry, domestic consumers and farms in the post-war era, Charles Wilson, president of General Electric Company and lately of the War Production Board, observed that in the twenty years from 1920 to 1940 the output per man-hour among manufacturing in this country increased 117 per cent; this despite the depression years. In other words, had we been operating at the 1919 level of productive efficiency more than twice the man-hours, or twenty million additional workers, would have been required to turn out our 1943 schedule of war production. This would have been impossible and prosecution of the war would have suffered thereby.

Opinions and estimates vary as to the probable immediate post-war electrical demand, but the belief is widely held that, following reconversion, the pent-up demand for goods and new construction will fully offset the loss of war production load. But it is long-range planning, as mentioned by Mr. Wilson, that will carry the curve steadily upward, as it did in the period between wars; and by further boosting productive efficiency through still greater use of electric power, this country should be able to maintain prosperity at home and meet competition from abroad.

Expansion Problems Encountered in Design of Steam Generating Units

By H. LIESSENBERG and DR. M. J. FISH

Combustion Engineering Company

The increase in size, complexity and high operating temperatures to which various parts of the modern steam generating unit is subjected, introduce many problems in expansion which must be anticipated by the designer, but which may not be appreciated by the user. These problems and their solution are here reviewed.

IN large central power stations, the trend during the past decade has been to build larger and still larger steam generating units. These Behemoths are not just "boilers" but are self-contained units comprising the boiler, superheater, economizer, air heater, coal pulverizers, forced- and induced-draft fans with all the accessory equipment which is necessary for their successful operation. Some idea of the size of such a complete unit can be obtained by realizing that its overall height is about that of a ten-story building. Furnaces have been built with a cross-section of 25 by 55 ft at the widest portion and a height of 70 ft. Such a space is large enough to enclose a few fair sized houses. An output of 1,000,000 lb of steam per hour which is equivalent to an evaporation of 120,000 gallons of water per hour is not uncommon. Furnace temperatures of 2200 F, saturated steam at 600 F and superheated steam at 950 F are responsible for a host of problems related to thermal expansion.

Upper drums are supported either by resting upon structural steel or by hanging from overhead steel by means of round rods acting as U-straps at each end of the drum as illustrated in Fig. 1. When the drum is supported from below, it rests on a casting which is known as a "drum chair." For very long drums where the expansion movements are large, these chairs rest on rollers so that there is less frictional resistance to motion. Otherwise, the friction forces would tend to buckle the web of the supporting beam. The usual practice in the extremely large units is to make use of overhead steel for supporting the drum. The hanger rods are furnished either with rockers or rollers, both of which rest upon the structural steel. The rocker assembly allows the rod to swing slightly when the drum expands and thus eliminates the presence of bending stresses in the U-strap. The roller assembly allows free movement and accomplishes the same purpose. In extreme cases, these rods are 5 in. in diameter and 25 ft in length. They are placed outside the furnace to avoid being subjected to intense heat. Naturally, the portion of the U-strap which hugs the drum tends to become as hot as the latter. Radiation and convection dissipate the heat to the surrounding atmosphere. The rods will elongate slightly due to their gain in temperature with the result that the upper boiler drums will be found slightly lower during operation than when in a cold state, if measurements are taken from the overhead supporting steel.

The lower boiler drum presents many interesting problems due to expansion and to loads. If the boiler tubes are not too flexible and are almost straight, the lower drum may be supported entirely by these boiler tubes. Then, the vertical expansion movements are guided by specially constructed drum guides which prevent undue rotation of the lower drum. These guides must have sufficient clearance to allow for the complete downward movement of the lower drum. The extent of this movement depends upon the distance between the upper and lower drums as well as the saturated steam temperature. When the boiler tubes which connect the upper drums with the lower one are of flexible shapes rather than straight, they must be analyzed for their load-carrying ability. The load may consist of downtake pipes or tubes supported by the lower drum, the lower drum itself, baffles and the water in the boiler tubes and drum.

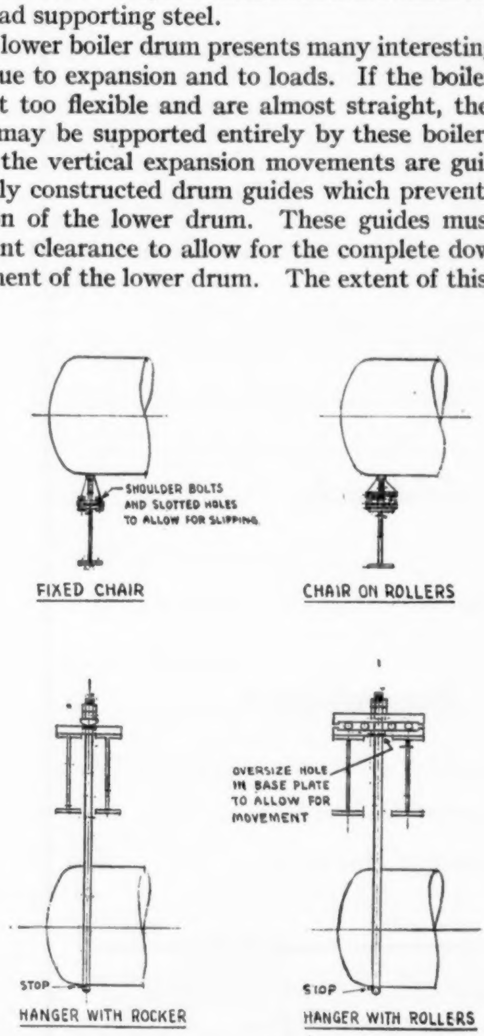


Fig. 1—Methods of hanging upper drums

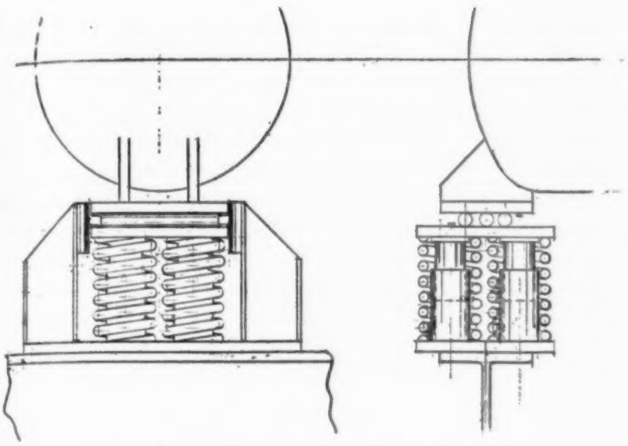


Fig. 2—Spring supports under lower drum

To limit the amount of load carried by these flexible boiler tubes so that the resultant stresses will not be too high, a portion of the weight is transferred to supporting structural steel beneath the lower drum. Then, the drum rests on spring supports which allow for the vertical expansion of the boiler tubes as shown in Fig. 2. To determine the size and number of these springs, a careful engineering analysis of all the contributing factors must be made.

For good heat transfer, the hot gas flow is guided over the boiler tubes by means of baffles made from refractory tile or from alloy steel. Special spaces between each tile shape in the refractory baffle together with recesses in the side walls are made, so that when expansion has taken place, there is almost no gas leakage between the different passes of the boiler and the economizer (Fig. 3).

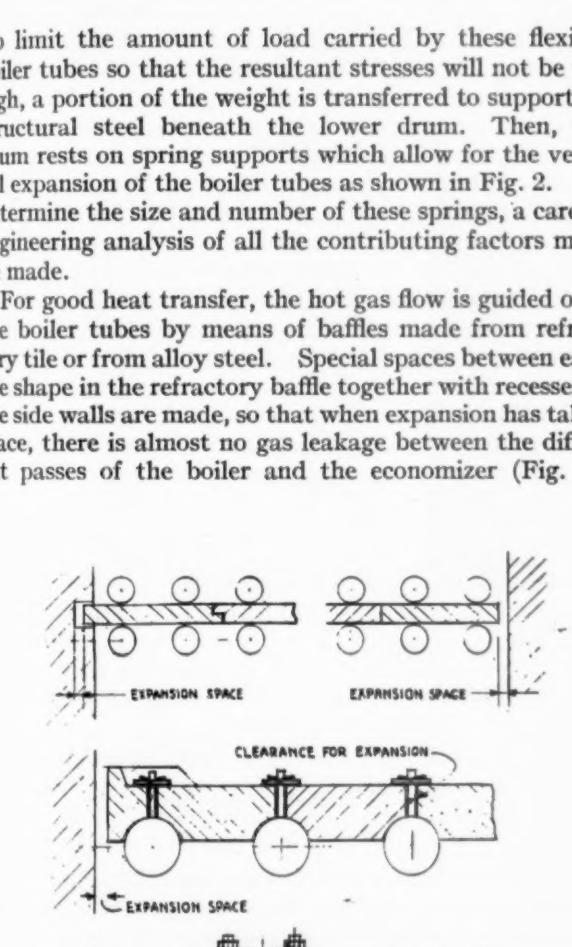


Fig. 3—Baffle attachments to allow for expansion

The alloy steel baffle may be of corrugated plate which will allow for the difference in expansion between itself and the tube to which it is bolted. Another design is to have the alloy baffle of plain plate with flexible end seals at the side walls. These flexible seals allow for expansion of the plate in several directions. Such an arrangement is an effective means of discouraging short-circuiting of gases. Sufficient clearance is provided between the boiler tubes closest to the side wall and the side wall itself. When the upper drums and the mud-drum expand longitudinally this clearance becomes smaller but must be sufficient for gas passage. Naturally, when the furnace is very wide, these drum movements are considerable.

In many designs of large steam generating units, a continuation of one baffle rests on the soot hopper as shown in Fig. 4. The soot hopper is stationary, while the baffle moves downward with the expansion of the

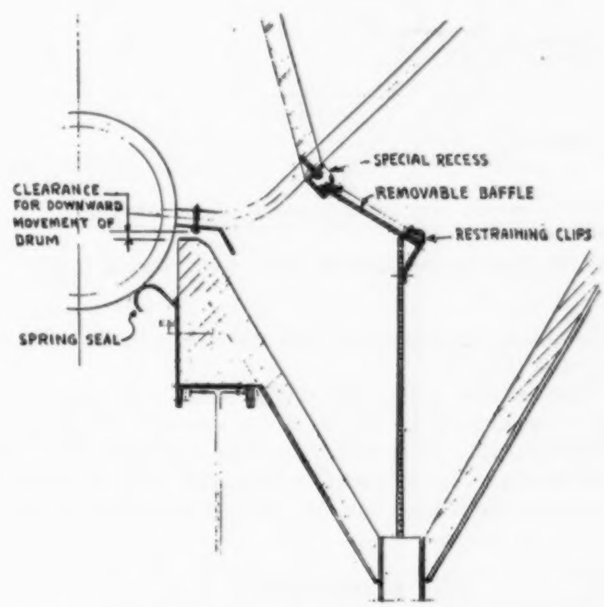


Fig. 4—Typical soot-hopper baffle and seal at lower drum

boiler tubes. If the baffle continuation is made of alloy steel to withstand the elevated temperature, it is designed to move in a special recess. When the arrangement of gas flow is such that this particular baffle separates the gases at the rear portion of the boiler tubes from the gases at the economizer exit, painstaking efforts must be made to see that the sliding seal arrangement is tight. This is due to the fact that the gas pressure drop through the economizer is considerable.

Almost all of these units have the inside of one of the upper drums fitted with a special arrangement which minimizes the carryover into the turbine of solid salts which are present in the feedwater. The feedwater which enters the drum is treated by chemicals and is also used for washing out insoluble solids which have been retained in the steam. This is done by bubbling the steam through the feedwater prior to the vapor passing into the superheater. This whole general system is known as the "Drum Internals." Since the incoming feedwater is at a considerably lower temperature than the saturated steam in the same drum, provision must be made in the feedwater piping for sufficient flexibility

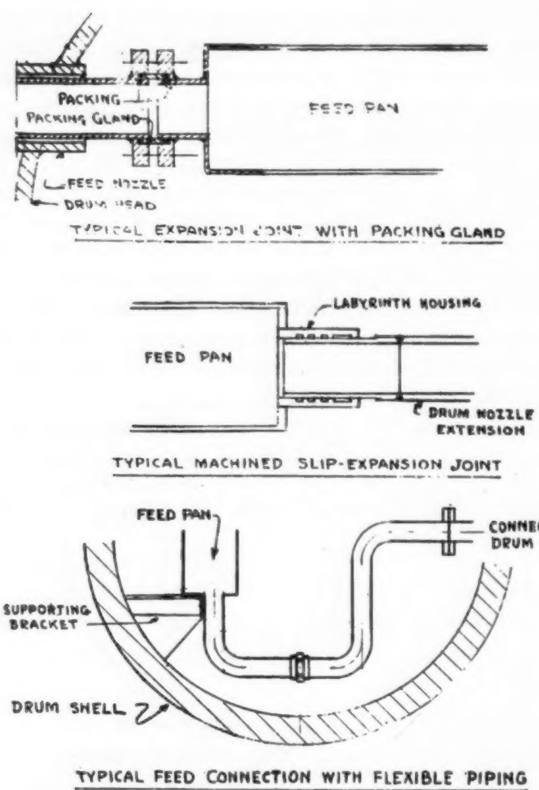


Fig. 5—Feed connection to drum with flexible piping

to combat the effects of this difference in thermal expansion (Fig. 5).

The outside or gas side of the boiler and superheater tubes are cleaned by means of soot blowers which have a rotating tube or element inserted through the boiler side walls. This element is equipped with expanding-type nozzles welded into it. When saturated steam is

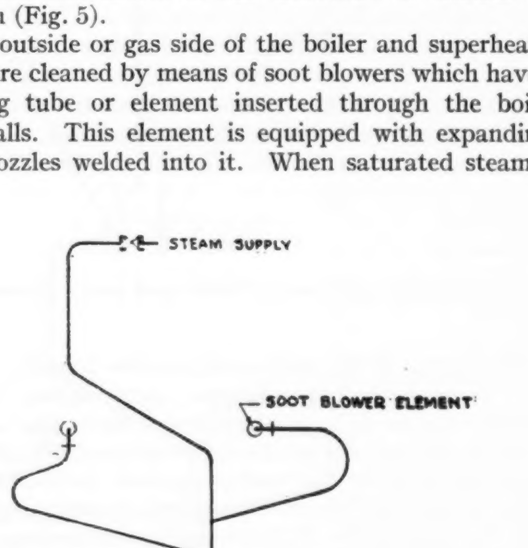


Fig. 6—Soot-blower piping arranged for flexibility

used, there is danger of the accompanying condensate, at high velocity, cutting the boiler and superheater tubes, if the soot blower is not located correctly. In some cases, superheated steam flows through the soot blower element and out of the nozzles. These nozzles must be located to guarantee their alignment with the spaces between the boiler tubes in order not to impinge upon the latter. Since most of the soot blower elements are of an alloy which has a different coefficient of expansion from that of the carbon-steel tube and operates at a different temperature, the spacing between the nozzles at room temperature is different from that between the boiler tubes, in order to have the spacing the same when

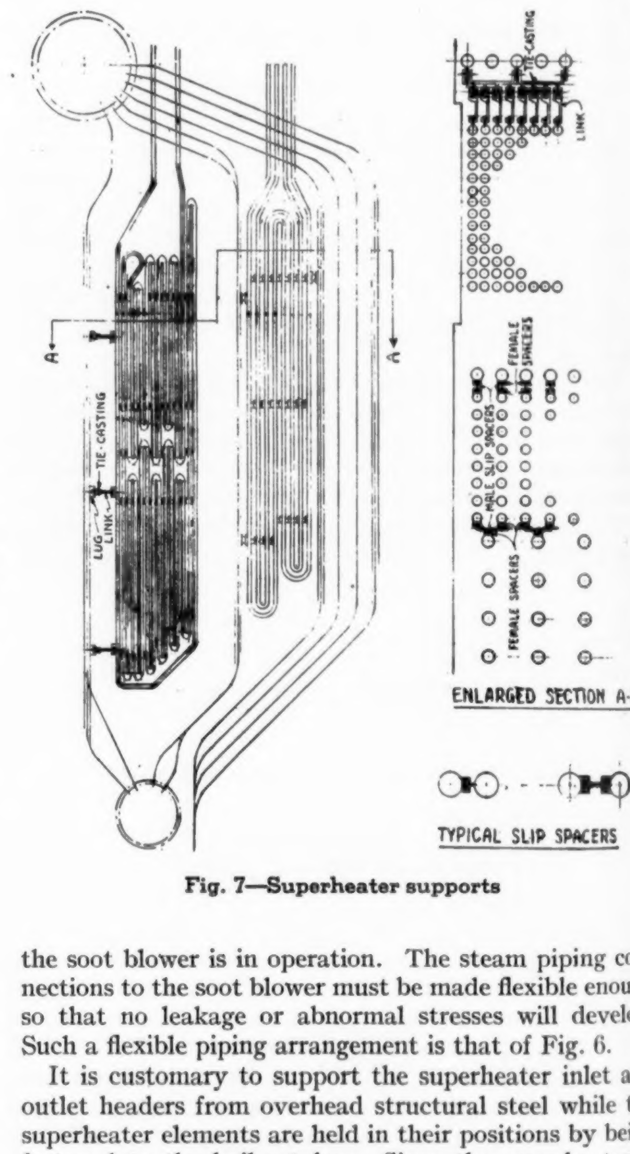


Fig. 7—Superheater supports

the soot blower is in operation. The steam piping connections to the soot blower must be made flexible enough so that no leakage or abnormal stresses will develop. Such a flexible piping arrangement is that of Fig. 6.

It is customary to support the superheater inlet and outlet headers from overhead structural steel while the superheater elements are held in their positions by being fastened to the boiler tubes. Since the superheater is subjected to a higher temperature than the boiler, a special link tie or spacer casting allows the superheater to slide along the boiler tubes (Fig. 7). The portion of the superheater adjacent to the outlet header is subjected to the maximum steam temperature and is manufactured from high-temperature steel. Due to the differences in the coefficients of linear expansion and in the temperatures, special male and female spacer castings between the elements allow free movement.

A common method of holding the superheated steam

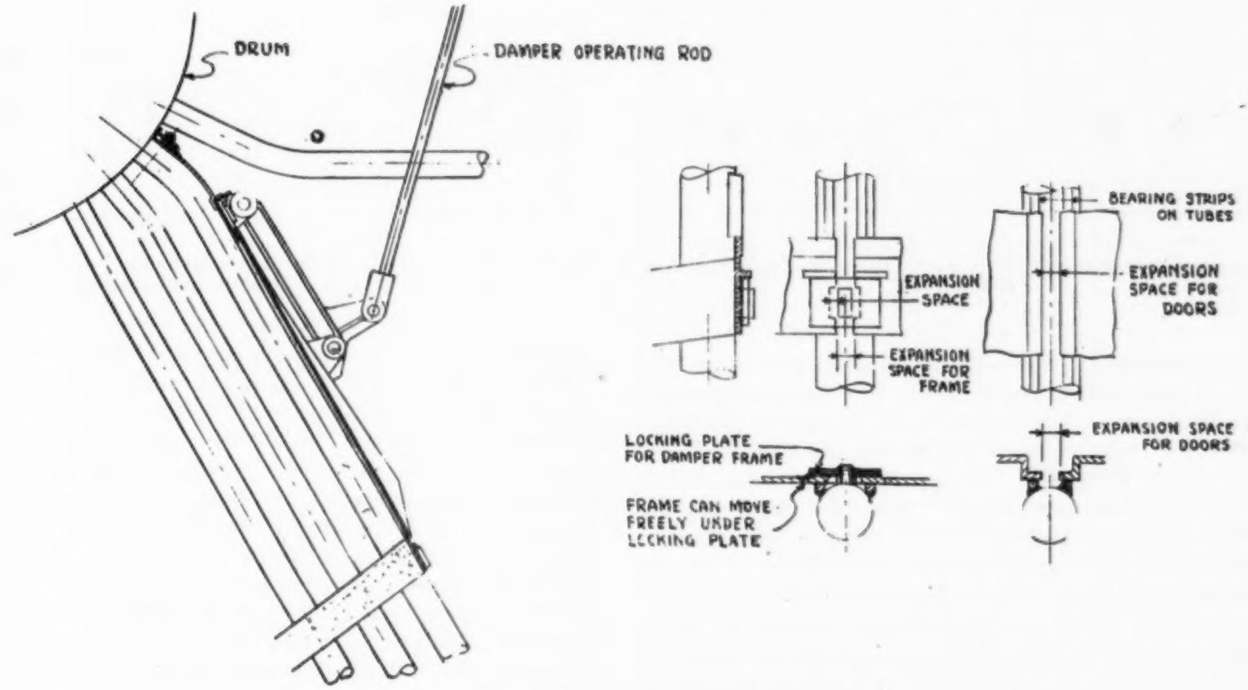


Fig. 8—Bypass damper attached to boiler tubes

temperature to a minimum variation is to install a bypass damper at a strategic position in the boiler tubes. When this damper is open, part of the gases short-circuit the superheater so that its heat absorption becomes less. The damper is of high alloy steel construction and consists of a movable blade and frame similar to a door. The frame can be fastened to the boiler tubes as in Fig. 8. These damper constructions require special study of their expansion joints. The latter serve the purpose of allowing the damper frames to move with the tubes in a vertical direction and to move freely across the furnace width when expansion and contraction take place. The provisions for expansion prevent warping of the frame and eliminate stresses being built up in the supporting boiler tubes.

Economizers of the horizontal fin-tube variety are placed in an adequate frame integral with the boiler. The gas flow which leaves the boiler tubes passes over the economizer tubes and transmits heat to the feedwater. The feedwater usually enters the economizer in the bottom row of tubes and leaves at the top previous to entering the drum (Fig. 9). Both the bottom and top rows of economizer tubes are left "floating" so that they will be flexible enough to withstand a variation in movement between them and the external feedwater piping connections. Formerly, the economizer was supported from overhead steel by means of alloy steel hanger rods. These rods were subjected to the temperature of the gas stream and therefore allowed the horizontal economizer to move downward a considerable distance. Research and development have brought about an alternate design whereby water-cooled tubes are used for supporting the economizer. The lower expansion coefficient of carbon steel in addition to the lower temperature of the cooling water have almost eliminated this downward movement. The piping connection from the economizer outlet to the boiler drum is always designed with sufficient flexibility to prevent leakage at the joint connections.

Hot-air ducts serve the purpose of conveying preheated air to the furnace. Other ducts carry hot air to the coal pulverizer for drying the coal during the grinding operation. The preheated air for combustion has a temperature of about 550 F, while that for drying the

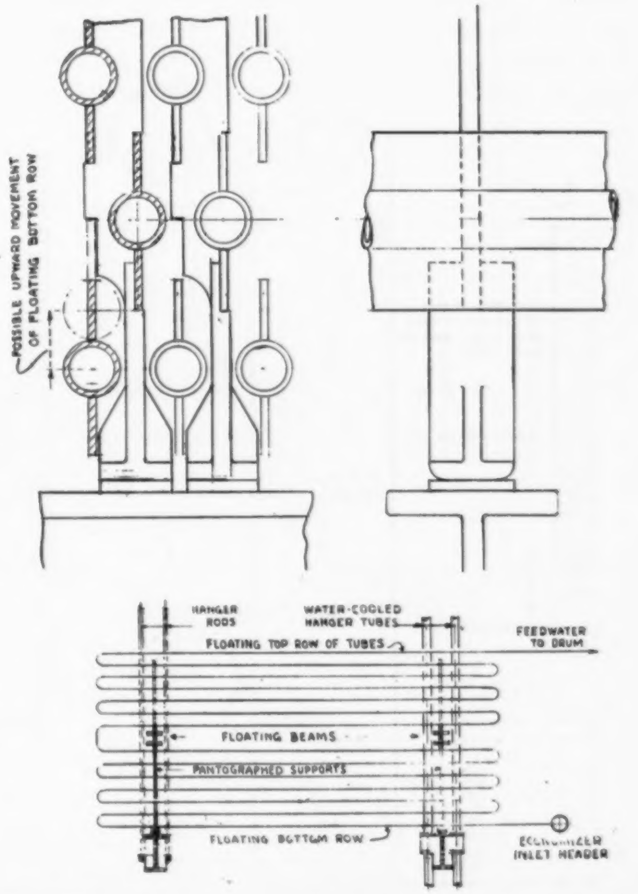


Fig. 9—Showing how expansion is met in an economizer

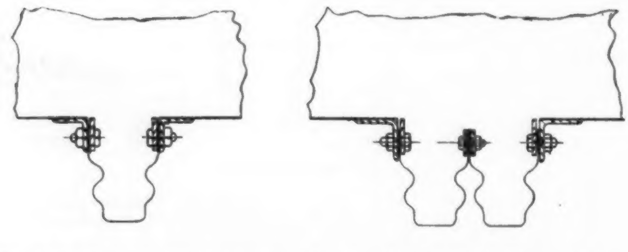


Fig. 10—Expansion joints for ducts, showing single and double bellows

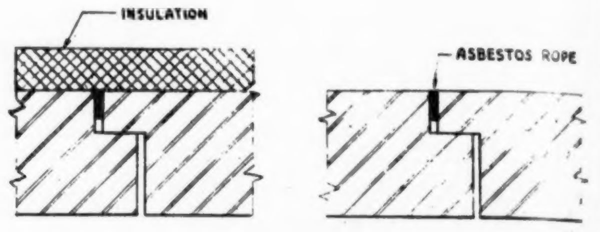


Fig. 12—Plan sections of vertical expansion joints in firebrick walls, with and without insulation

coal is tempered to the neighborhood of 350 F by mixing with a sufficient amount of air at room temperature. Gas ducts are on the outlet side of the steam generator and guide the combustion gases through the induced-draft fan to the stack. The gas ducts are subjected to temperatures of about 600 F. Since the power plant is a maze of piping, structural steel, equipment, and other interferences, it is necessary for these ducts to change direction and shape. Their thermal expansions are compensated by means of bellows-type expansion joints which operate like an accordion and are shown in Fig. 10. Thus, misalignment of bearing surfaces is prevented, joints are kept tight, and thrusts and stresses at fans, burners, and stacks are kept to a minimum. At one particular installation some of the beams which reinforce the duct were only partially covered by the insulation. The difference in temperature between the portion of the beams touching the duct and the portion exposed to the atmosphere caused considerable bowing of these beams. When completely covered by insulation, this bowing disappeared.

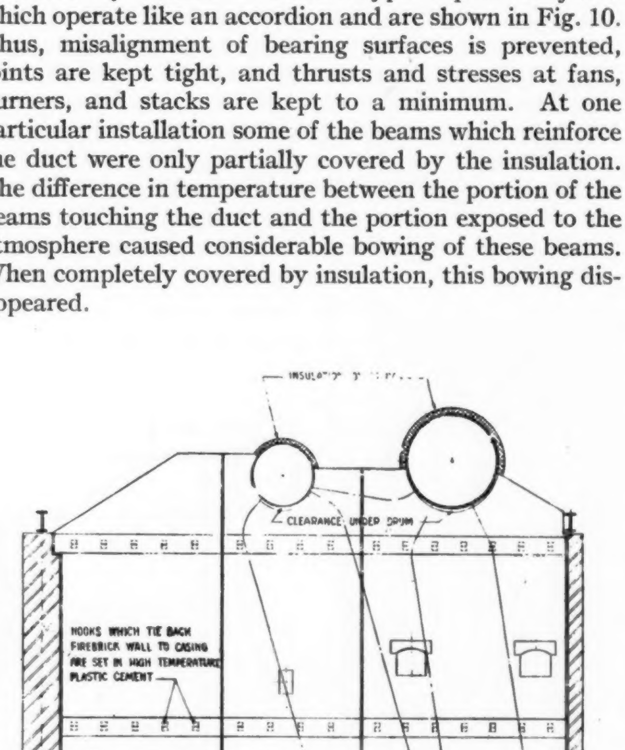


Fig. 11—Location of expansion clearances in brickwork

Furnaces are either of the water-wall type or have a firebrick setting. Both of these constructions have their own peculiar problems due to expansion as well as other influences. In the brickset furnace, space must be provided underneath the lower or mud drum due to its downward movement. Fig. 11 shows the location of some clearances in the brickwork. Similarly, space must be provided under the top drums due to their diametral growth and extension of hanger rods in addition to the upward expansion of the brickwall when the unit is in operation. These spaces must be packed with soft material which withstands high temperatures in order to minimize the leakage of gases and yet allow for easy movement of the drums into their hot location. Asbestos rope, a plastic mixture of asbestos and insulating cement are such materials. Sometimes, the bottom of the firebrick wall in the latter passes of the boiler is at a higher elevation than is the bottom of the firebrick wall in the furnace proper. Then, there is a difference in the amount of expansion between these portions of the walls. This is due to the difference in temperature of the two zones under consideration as well as the differences in the heights. A vertical expansion joint is provided between such walls to obviate shearing of the brickwork during expansion. These joints are shaped to present a path with two right-angle turns to any leaking gas. The addition of an asbestos packing provides an effective seal arrangement (Fig. 12). Vertical expansion joints at strategic positions in the wall, as well as in the corners, provide ample space for lengthwise expansion of the brickwork. Formerly, arches were in frequent use over door openings. The rise of the arch at the crown and the thrust at the abutments became a source of damage to the arch and to the surrounding brickwork. Consequently, present design has replaced the arch in these places by a single lintel brick.

Steam generators which have water-cooled furnaces constructed of tubes on close centers, backed up by specially shaped refractory tile and insulating block with a sheet-metal casing as an enclosure, have lower outside furnace-wall temperatures than do the brick-set furnaces. This is so despite the fact that the combustion in the water-wall furnace usually takes place at higher temperatures than does the combustion in the furnaces with brick setting. In these water-wall furnaces, the special shaped tiles are cemented to the water-wall tubes and rest on pegs which are welded onto the tubes. The tile moves with the tube when there is expansion or contraction. Special corner tiles, which are supported on the casing structural steel, provide vertical expansion joints at the furnace corners and allow lateral movement of the water wall.

The roofs of these furnaces present many interesting problems which must be solved by sound analyses. The

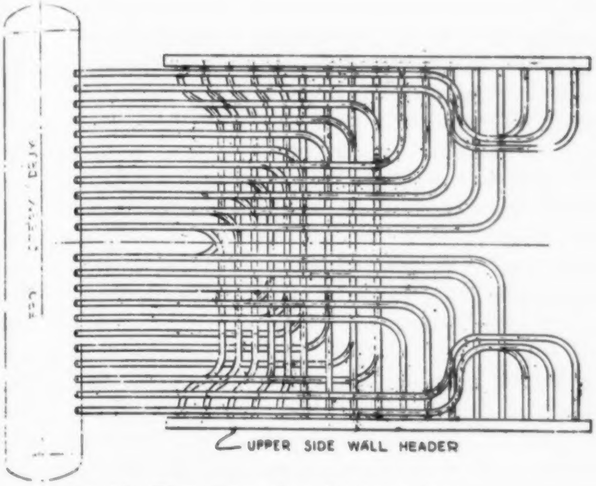


Fig. 13—Plan view of roof-riser tubes

tubes, which are commonly called roof riser tubes, carry the steam circulation from the upper furnace side-wall headers into the upper front steam drum. To accomplish this, these roof riser tubes have right-angle bends and are subjected to expansions in horizontal and vertical planes (Fig. 13). The tube seats at both the header and drum ends have three terminal forces and three terminal couples in planes at right angles to each other. The total combined stress must be kept below the value at which damage will be done to the tube seats in the drum or headers. A leakage of steam and water mixture at these tube seats may be symptoms of high stresses and plastic flow of metal. In some furnace roof arrangements, these roof riser tubes pass through piers built up of refractory hydraulic cement. Fig. 14 shows these piers which form part of the refractory roof near the doors which are used when lancing the superheater tubes. When this cement is poured around the tubes during the erection of the unit, provision must be made for three-dimensional expansion so that the piers will not crack. Other tubes, called the furnace roof tubes, which carry a steam and water mixture from the upper front wall of the furnace to the upper front drum, are arranged in parallel rows and have refractory and insulation on their outside. These tubes must be able to carry this load by beam action, in addition to being sufficiently flexible to withstand the effect of the expansion forces. Overhead rods with rocker bearings are attached to lugs on the tubes to provide an additional reaction for the loads. The continuous beam effect is of great assistance in a safe design.

In recent years, much analytical work has been done on the stresses of high-temperature pipe lines. All these researches have found useful application in the design of the waterwalls of the steam generator. Often, space considerations do not allow for enough bends and expansion loops in the tubes and pipes to keep the stresses within reasonable limits even with the aid of cold springing. In such cases, radical measures must be taken so that the entire design of the huge structure is changed. In one very large unit which has been installed in a public utility plant, five $10^3/_4$-in. downcomer pipes feed water from the lower drum into a 14-in. horizontal header which is at a lower elevation than the furnace. From this header, forty $3^1/_2$-in. tubes lead the water for circulation into the front and rear furnace walls. Thirty additional tubes of the same size carry the water into the two lower side-wall headers for circulation up into the side walls. The five downcomer pipes expand downward from the upper drum, while the water wall expands downward from the structural steel truss which supports it. The difference in downward movements of the furnace walls and the downcomer pipes, in addition to the difference in moments of inertia of the $10^3/_4$-in.

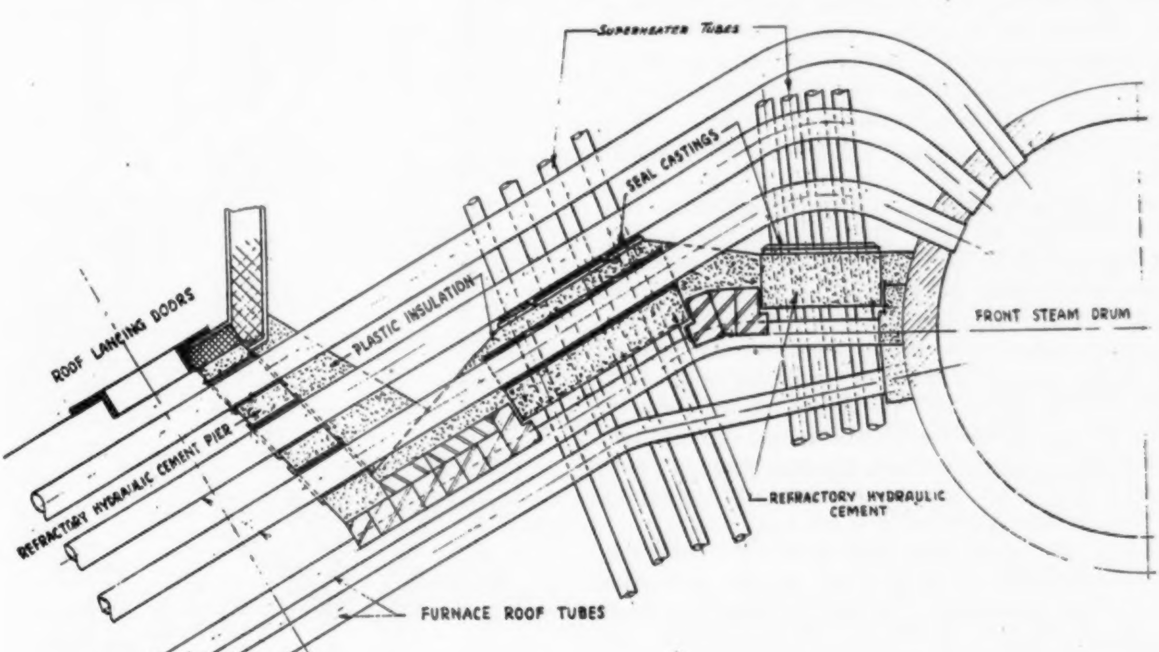


Fig. 14—Section through roof at lancing doors and superheater seals

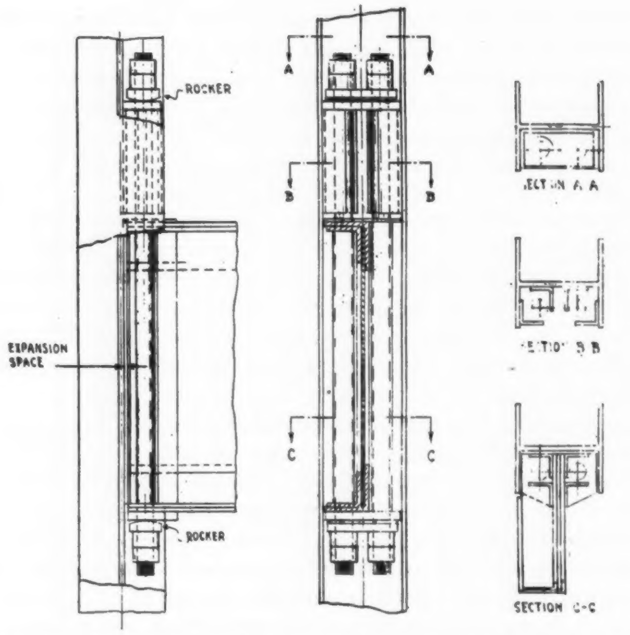


Fig. 15—Girder supported on hangers with rockers to allow for expansion

downcomer pipes and the $3^1/_2$-in. tubes were responsible for a difficult expansion problem. The engineering analysis of this problem was arduous. Due to lack of room, cold springing of the tubes in addition to the expansion loops was necessary to keep the combined stresses due to high temperature expansion and to fluid pressure within the limits of the A.S.M.E. Boiler Code.

If the water-wall furnace tubes were not fastened to the outside casing at frequent intervals along their elevation, they would bow into the furnace a considerable distance. Such a condition would be injurious to the furnace as the hot gases would be able to get in back of the tubes and destroy the insulation in course of time. Tying the furnace tubes to the casing, limits the amount that the tubes can curve. During operation of the furnace, these tubes expand relative to the casing so that an arrangement of slotted lugs allows the tube to move freely in a vertical direction and yet take advantage of the tieback.

The main steam lead from the superheater outlet pipe to the turbine must be made sufficiently flexible so that the end thrusts and stresses at both the turbine and superheater are kept within a safe limit. The piping at the turbine end can be complicated by branch piping. The difficult and involved stress analysis is then often checked by tests made on a small model of the piping built to exact scale. In the design of any exterior piping connecting to the drums, such as the blowoff piping or feedwater connection from the economizer, the longitudinal drum movements must be considered in addition to the piping itself so that sufficient flexibility is insured.

Ordinarily, the supporting structural steel for these mammoth steam generators does not require any extra precautions for expansion. If the supports are kept at a sufficient distance from the furnace sides, there will be ample space for an effective circulation of air about the steel. Convection aided by radiation will reduce the temperature of the steel so that the connections of girders to columns will not present any unusual problem. In many instances, where the water wall is supported at an intermediate position in the furnace height, the supporting girders are exposed to a much higher temperature than the remainder of the steel. Such a condition calls for special study and design. In several installations, the front wall furnace girders have been fastened to the columns by means of vertical hanger rods on rocker bearings (Fig. 15). Thus, the expansion movements take place without their being transmitted into the columns as would be the case if fixed connections were used. Fig. 16 depicts the cross-section of a steam-generating unit where some of the expansion problems are solved by supporting furnace, water walls, boiler, drums, superheater and economizer from overhead structural steel. The entire weight of the front- and side-wall tubes, as well as the basket structure mentioned below, is supported from the top header. The insulation is carried on the casing steel. Lugs welded onto the headers furnish a method of connection to the structural steel by means of rods. A rigid steel basket frame, which is spring-supported from the bottom side-wall headers, supports the sloping front and rear lower portion of the furnace. The straight portion of the furnace rear-wall tubes is

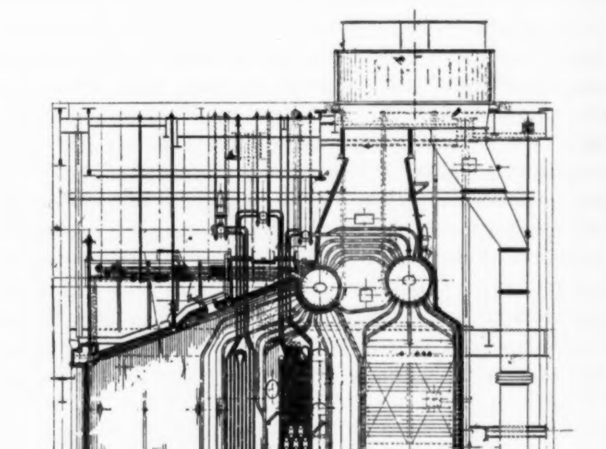


Fig. 16—Cross-section of steam generating unit in which furnace, water walls, boiler, drums, superheater and economizer are carried from overhead structural steel

supported by structural steel. This latter rests on the rigid basket frame and moves up and down with it. Thus, the stresses at the point of entry of the rear furnace tubes in the lower drum are kept low. Downcomer tubes are used instead of pipes for feeding circulation water into the furnace walls. The entire expansion of the furnace is downward from the top. There is a difference in downward expansion between the side-wall lower headers and the front or rear-wall lower headers of about $^1/_2$ in. due to the steel basket. This small amount is readily absorbed by the elaborate spring system at the bottom.

Since the preheated air for drying of coal during its grinding operation is about 350 F, slotted holes are provided on one side of the pulverizer base plate to allow for free movement. This provision protects the driveshaft coupling from misalignment and damage. The burners are rigidly secured to the furnace steel, while the coal pulverizers are kept in position by having one side firmly fastened to the foundation. Allowance for expansion between the burner and mill must be accounted for in the piping between them. Space considerations usually do not allow for the large expansion loops that would be necessary in this large diameter piping. A flexible pipe coupling is used to allow for the expansion and contraction of the pipe as well as some angular deflection.

Air heaters, are of the plate, tubular, or the rotating element type. The plate heater is made up of a series of elements, assembled in a casing and supported by steel framework. Angles or bars are welded to the plates and act as spacers or baffles to direct the gas and air flow so that even distribution over the entire plate surfaces is obtained. The gas and air are arranged to flow in alternate parallel layers in accordance with the counterflow principle. In order to prevent mixing of the gas and air at both the inlet and outlet to the preheater, seal plates are provided. These seals are flexible so that they are effective when the apparatus has expanded during operation. The preheated air is often obtained by employing a tubular heater. In this heater, the tubes are arranged vertically with the gas flow inside the tubes and air directed by metal baffles on the outside of the tubes. The baffling is so arranged, that the heat transmission from the gas flow to the air is efficient. These baffles are fitted about the tubes so that leakage of air from one pass to another is kept at a minimum. The tubular air heater is supported by structural steel either at its top or bottom. The free end is then connected to the ductwork by means of the same type of accordion bellows that is used to take care of expansion problems in the ductwork (Fig. 10). The air preheater which employs rotating elements is an ingenious mechanism whereby the available heat in the gas chamber is liberated to the colder incoming air by rotation of sections which isolate the gas from the air flow. Heaters of this type are much smaller and lighter than the others for the same value of heat recovery. The allowance for expansion of the elements during operation is combined with the problem of fluid leakage. Axial seals between the rotor and support and circumferential seals between rotor and housing keep leakage to a negligible amount.

It will be apparent from the foregoing that the solutions to the problems caused by thermal expansion play an important role in the design and operation of the modern steam generator.

Starting Pulverized-Coal-Fired Boilers

A few practical pointers on starting boilers when direct-fired with pulverized coal, and description of the two commonly employed methods, namely, raising pressure by use of large oil or gas burners and by intermittent use of the pulverizers with torches for lighting of the coal burners.

By ALAN RUCH
Combustion Engineering Company

TWO methods of raising pressure and starting direct-fired pulverized-coal-burning boilers are in common use. Each entails certain steps and precautions with which new operators should become thoroughly familiar.

With the first, oil or gas burners of sufficient size to raise the pressure to normal and to generate a small amount of steam are employed. That is, the boiler is first brought up to operating pressure and cut in on the line before the mills are started. For this purpose, a light fuel oil is generally used, as the expense of providing heating equipment for heavier oil is not justified unless combination burners have been installed to use oil as an alternate fuel. Where gas is relatively inexpensive it is often employed for such starting.

In the second method intermittent firing with pulverized coal is employed. In this case oil or gas torches are provided. They should be just large enough to light off the coal burners, and the pulverizer is operated for "on" and "off" periods of five to fifteen minutes, or long enough to bring the unit up to operating pressure in a reasonable time, as discussed later on.

From the operators' point of view, the first method is generally considered the more desirable, as the boiler is brought up to pressure at a constant rate and hot air for drying the coal is available from the air preheater when the mills are started.

When light oils are used for this purpose mechanical atomizing burners are satisfactory, but air- or steam-atomizing burners can be operated over a wider range in capacity and tend to remain clean for longer periods. Moreover, if heavy oil is used for starting, it may be difficult to avoid smoke and obtain complete combustion with mechanical atomization in a cold furnace.

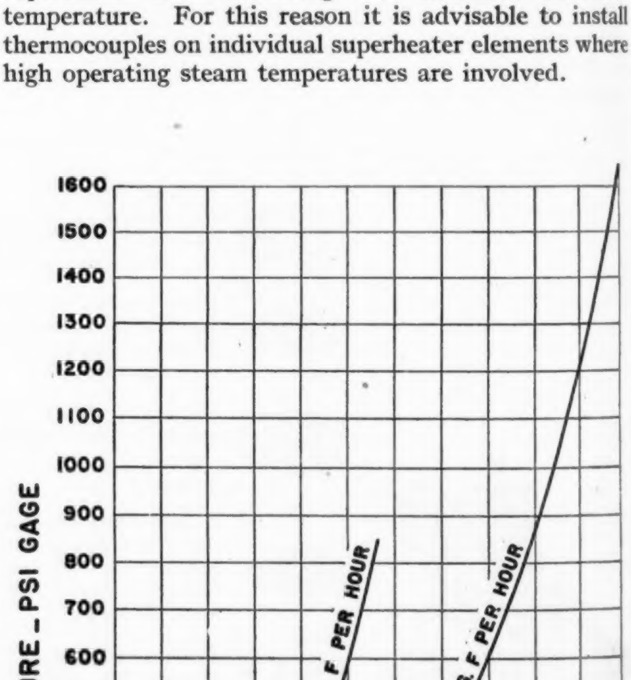
Whichever method of starting is used, the unit and all of its auxiliary equipment should first be inspected to make sure that everything is ready for service. This includes seeing that all handhole caps and manhole covers are in place; access doors closed; control dampers free; blowoff and drain valves closed; gage cocks open; and vent valve on the steam drum open.

Then the boiler is filled to the proper level,[1] which is usually about two or three inches in the gage glass; the vent valve in the superheater outlet header is opened; the fans started, and the forced-draft dampers adjusted to give the correct windbox pressure for lighting off.

[1] When starting a boiler for the first time it is well to fill it until water shows in the gage; then drain enough to be sure that it will drain from the glass. Occasionally an error is made in putting in piping which allows water to be trapped in the gage and a level may show even though there is little or no water in the boiler. This precaution will obviate damage if such a piping error has been made.

In general, a boiler should be brought up to operating pressure as slowly as plant conditions permit, so as to avoid unnecessary expansion strains. It is usual to allow from one to two hours warming-up time for boilers operating under 650 psi and three to five hours for high-pressure boilers. The schedule for warming up a higher pressure boiler is based on raising the temperature at a uniform rate. For units operating at around 850 psi a rate of about 125 deg F per hour is common, whereas 80 to 90 deg F per hour is generally used for boilers operating at 1250 to 1450 psi. The accompanying curve shows the gage pressures that will correspond to a constant temperature rise, at any time interval after lighting off.

The time for raising pressure must also take the superheater into consideration; for, during the rise in pressure, steam flow through the superheater is limited by the capacity of the drain. Hence, firing rates must be maintained low enough to prevent the steam leaving the superheater from exceeding the maximum allowable temperature. For this reason it is advisable to install thermocouples on individual superheater elements where high operating steam temperatures are involved.



Curve showing gage pressures corresponding to a constant temperature rise for different time intervals.

Starting with Oil or Gas

Briefly, the procedure from there on for starting, when employing the first method, includes the following steps:

1. Light the oil burner and adjust the uptake damper so as to obtain the proper amount of air for smokeless combustion.

2. Adjust the firing rate so as to raise the steam pressure at the desired rate.

3. As the steam pressure increases, the superheater vent can be throttled slowly, provided a means for determining vented steam temperature or superheater element is available.

4. When operating pressure has been attained, cut the boiler into the line and then start the mill.

5. If a Ljungstrom air preheater is installed, it must be started before the gas temperature entering it reaches 350 F; and, in any case, it should be started before starting the pulverizer so that hot air will be available to the latter. The preheater soot blowers are operated as soon as full pressure is available, either immediately before or after starting the first mill.

6. Start the first mill and open the hot-air dampers, allowing it to run for 5 to 10 minutes before starting the coal feed. Then open the exhauster damper to obtain the desired primary air pressure for lighting the pulverized coal burners. This will usually be about half open.

7. Next, start the feeder and operate it at full speed for about 20 seconds and cut back to about half speed.

8. Observe the burners for appearance of coal, to be sure that immediate ignition is obtained; adjusting the burners and forced-draft pressure as required to bring the ignition point to the burners and obtain proper combustion conditions. Then reduce the firing rate on the oil burner to a minimum, using it as a pilot light until conditions within the furnace are stabilized.

9. Where more than one pulverizer is provided, they should be made ready one at a time and put in service as needed to meet the steam demand. The second should be cut in when the first has reached about 80 per cent of its capacity.

Starting with Coal by Intermittent Firing

In the second, or intermittent firing method of starting, and after the previously mentioned preliminary steps have been taken, the following procedure is observed:

1. Increase the furnace draft to allow for the additional air that will be added when the mill exhauster is started, the amount of which will vary with the size of the furnace and the number of mills.

2. Check the lighting torches to make sure they are burning steadily.

3. Start the pulverizer; recheck the torches, and if burning steadily, start the feeder. Run the feeder at full speed for about 20 sec and reduce to half speed.

4. Watch the burners for the appearance of coal and be sure proper ignition is obtained. In case the coal does not ignite promptly, or if a lighting torch becomes extinguished, stop the pulverizer and cut off the torches. Relight only after furnace has been thoroughly purged.

5. When stable ignition has been obtained, the coal feed should be cut back as far as possible.

6. When the desired firing period has expired, shut off the coal feed and run the pulverizer empty for a short time before shutting it down. Close the superheater vent. If it is important to conserve the quantity of oil used, the torches can be cut off each time the pulverizer is shut down; but both the forced- and induced-draft fans must be kept operating.

7. Where a Ljungstrom air heater is installed it should be started not later than at the first "off" period and the dampers so adjusted that hot air to the pulverizer is taken from it.

8. After the "off" period has elapsed the pulverizer should be started as before. Just before each light-off the superheater vent should be opened and immediately after shutting down the pulverizer it should be closed.

9. When the boiler is up to operating pressure, cut it into the line and adjust the firing rate to carry the load. The lighting torches can be cut off as soon as stable operation has been established.

Operating Bowl Mills

The bowl mill rejects slate, pyrites and tram iron through a reject spout in the mill base. The principal cause of coal spilling from a reject spout is insufficient air flow through the mill, or excessive coal feed. Coal spillage may also be caused by low air temperature, worn grinding parts or improper adjustment of rolls and spring pressures.

The suction under the bowl is held at about 0.5 to 1.0 in. wg at all loads. Operators should not attempt to eliminate coal spillage by increasing the suction under the bowl. Excessive suction under the bowl may result in pulling lubricating oil from the gear case.

For good results the air temperature through the mill should be maintained high enough to give good drying. The mixture temperature of air and pulverized coal leaving the mill is generally maintained at about 185 F, plus or minus 10 deg F. Loss of capacity due to insufficient drying will begin to be apparent as the mixture temperature falls below approximately 175 F.

In general, burner operation improves as fineness increases, with a reduction in carbon losses and slagging troubles. The fineness of the pulverized coal then must be a compromise, with costs of pulverizing balanced against the cost of losses in efficiency due to unburned carbon and cost of maintaining clean heating surfaces. Fineness of the pulverized coal is one of many factors affecting the carbon losses and the slagging of heating surfaces.

Power consumption in kilowatt-hours per ton and maintenance costs in cents per ton of coal pulverized are lowest when the mill is operated continuously at full load. This condition can rarely be maintained on direct-fired steam generating units. When operating with partial loads on units fired by two or more mills power consumption and maintenance costs would be lowered if a mill were shut down completely when the load could be carried by the remaining mills serving the boiler. This method of attaining minimum pulverizing costs, however, is offset by the increased possibility of losing the load in case of interruption of coal feed or other accident on the mill, or mills in service. It cannot be used successfully if the load is subject to wide swings without warning.

Wear on pulverizer parts is a function of operating hours rather than of tons pulverized. Operating data should include a record of pulverizer service hours as it has been generally found that this is a more accurate guide in scheduling inspections and replacement of wearing parts.

Increase in Industrial Power, from 1939 to 1945

THE Federal Power Commission has just issued a report covering the supply and use of electric energy by manufacturing plants (including Government plants) and extracting industries for the years 1939–1945.

These data are based on reports of industrial producers of electric energy with plant capacities of 100 kw and over and on reports of establishments using in excess of 85 per cent of the electric energy consumed in manufacturing and extracting activities, the latter covering mining, petroleum and natural gas.

Some measure of the growth of industrial use of electric energy in the six-year period from 1939 through 1944 is afforded by the fact that although the total electric production from all sources for 1944 was 73.3 per cent greater than for 1939, the total industrial use more than doubled during this period. That is, manufacturing industries increased their requirements 104.7 per cent, from 70.5 billion kilowatt-hours in 1939 to 144.3 billion kilowatt-hours in 1944. The use of electric energy by extracting industries rose from 8.1 billion kilowatt-hours to 11.4 billion kilowatt-hours, an increase of over 40 per cent.

Chemical Industries Lead in Use of Electric Energy

As will be noted from Table 1, the three largest users of electric energy in 1944 were chemicals, iron and steel and nonferrous industries, in the order named; whereas in 1939, iron and steel, paper and chemicals comprised this group. That is, the chemical industry increased its requirements more than three-fold, iron and steel nearly doubled and non-ferrous metals three and a half times, but the paper industry increased only slightly. In 1944 chemicals, iron and steel, and nonferrous metals accounted for 46.1 per cent of the total energy used in manufacturing and extraction. Relatively, however, transportation showed the greatest percentage increase in kilowatt-hours consumed which was 18 times that used in 1939.

Indicative of large-scale production is the fact that in 1944 there were 505 industrial establishments, each using in excess of 50 million kilowatt-hours annually, and representing 52.1 per cent of the total, whereas in 1939 this group comprised only 216 establishments using 37.1 per cent of the total. Industries primarily responsible for the increase in the number of large plants were non-ferrous metals and chemicals.

In 1944, says the report, the total production of electric energy in the United States was approximately 280 billion kilowatt-hours, of which manufacturing and extracting industries accounted for 158.8 billion kilowatt-hours or 57 per cent. Of the 280 billion kilowatt-hours total, electric utilities produced 228.2 billion, or 81.6 per cent, and non-utility generated power was 51.3 billion kilowatt-hours, or 18.4 per cent—a ratio that has changed little during the six-year period. Table 2 shows this by years.

However, there has been considerable variation in the proportion of energy purchased by industrial establishments and that generated in their own plants. Of the energy generated and purchased by the country's industries in 1944, 70.3 per cent came from purchases and 29.7 per cent was privately generated. On the other hand, in 1939 only 61.7 per cent of the total was purchased and 38.3 per cent was generated. These figures do not, of

During the last six years industrial use of electricity has more than doubled, and three major industries accounted for over 46 per cent in 1944. Of the total used, 70.3 per cent was purchased and 29.7 per cent privately generated. Estimates for 1945 indicate that the total use will exceed that of 1944 by approximately 3 billion kilowatt-hours.

ELECTRIC ENERGY REQUIREMENTS OF MAJOR INDUSTRIES

1939 - 1945

INDUSTRY	Kilowatt-hours in Thousands						
	1939	1940	1941	1942	1943	1944	1945
MANUFACTURING							
Chemicals	9,746,551	12,602,120	16,397,198	21,670,716	28,684,939	29,163,354	29,528,327
Iron and Steel	12,245,004	14,809,440	18,703,024	20,315,682	22,363,895	23,289,908	23,945,254
Nonferrous Metals	5,953,282	7,805,000	10,663,413	15,375,189	23,495,314	20,765,278	19,025,955
Paper	9,096,930	10,005,735	11,184,836	11,269,570	10,985,396	11,037,527	11,450,111
Transportation Equipment	482,232	796,352	1,647,570	4,277,204	7,290,812	8,908,688	8,870,272
Textiles	6,800,071	7,393,882	9,118,609	9,793,736	9,376,931	8,815,882	9,124,499
Food	6,385,898	6,532,228	7,315,446	7,905,030	8,560,905	8,724,387	9,081,281
Petroleum and Coal	3,438,114	3,844,312	4,357,974	4,620,907	5,228,502	6,243,480	6,776,855
Machinery	1,985,407	2,549,106	3,634,326	4,816,038	5,811,274	5,861,275	6,039,291
Stone, Clay and Glass	4,851,242	5,300,870	6,546,798	6,967,797	6,069,685	5,099,529	5,272,940
Automobiles	2,467,383	3,042,304	3,668,349	3,454,189	4,572,123	4,661,755	4,843,932
Electrical Machinery	1,431,606	1,816,567	2,521,704	2,999,486	3,541,607	3,656,196	3,678,009
Rubber	1,584,434	1,652,461	2,073,173	1,754,152	2,137,446	2,494,054	2,812,987
Lumber	1,245,410	1,424,280	1,582,376	1,685,522	1,629,836	1,461,514	1,545,453
Printing	858,206	930,457	1,024,693	1,042,314	1,075,133	1,100,836	1,093,882
Miscellaneous	465,755	516,200	662,903	793,351	932,968	917,445	950,081
Furniture	605,045	679,052	830,403	844,992	885,965	867,368	908,127
Apparel	357,485	420,040	513,742	553,770	604,609	538,970	566,624
Leather	402,229	415,620	522,536	559,363	556,448	555,606	563,303
Tobacco	114,876	125,760	139,629	145,053	159,577	163,896	169,508
Total	70,518,166	82,661,786	103,108,700	120,844,070	143,963,665	144,318,968	146,285,441
EXTRACTING							
Coal Mining	3,524,559	3,938,116	4,181,315	4,856,306	5,187,952	5,237,694	5,456,010
Metal Mining	2,895,102	3,339,521	3,697,388	4,163,507	4,226,503	3,818,974	3,971,887
Nonmetallic Mining	828,216	938,700	1,131,268	1,230,236	1,346,494	1,348,327	1,438,243
Petroleum and Natural Gas	837,006	898,239	884,514	887,197	934,775	945,126	987,271
Total	8,084,883	9,114,576	9,894,485	11,137,246	11,675,814	11,350,121	11,853,[illegible]
GOVERNMENT							
Shipbuilding	179,992	249,820	413,474	734,372	985,933	1,155,031	1,288,223
Arsenal and Ordnance	90,384	133,325	319,357	808,952	1,109,184	1,099,960	1,322,999
Miscellaneous Manufacturing	171,019	230,903	195,957	374,306	790,555	826,578	959,819
Total	441,395	614,048	928,788	1,917,630	2,885,672	3,081,569	3,569,041
United States	79,044,444	92,390,410	113,931,973	133,898,946	158,525,151	158,750,658	161,657,853

Table 1

ELECTRIC ENERGY GENERATED IN THE UNITED STATES

1939 - 1944

Source of Supply	Kilowatt-hours in Billions						Percent Total Kilowatt-hours					
	1939	1940	1941	1942	1943	1944	1939	1940	1941	1942	1943	1944
							%	%	%	%	%	%
Electric Utilities*	127.6	141.8	164.8	186.0	217.7	228.2	79.1	78.8	79.1	79.8	81.4	81.6
Non-utility Producers*	33.7	38.1	43.5	47.2	49.8	51.3	20.9	21.2	20.9	20.2	18.6	18.4
All Producers	161.3	179.9	208.3	233.2	267.5	279.5	100.0	100.0	100.0	100.0	100.0	100.0

Left—Table 2

Below—Table 3

course, take into account steam produced in many process industries where power is purchased.

The chart, Fig. 1, represents the relative uses of electric energy by the principal industries arranged by geographical divisions. Within these divisons New York tops the states with over 25 billion kilowatt-hours, closely followed by Pennsylvania, Ohio, Illinois, California and Michigan, in the order named.

Electric generation and capacity by type of prime mover in 1944 are given in Table 3.

Based on estimates from manufacturers the report concludes that total use in 1945 will be approximately 3 billion kilowatt-hours in excess of the actual use as reported for 1943 and 1944 which represented the peak years to date.

ELECTRIC GENERATION AND GENERATING CAPACITY BY TYPE OF PRIME MOVER 1944

(Kilowatt-hours and Kilowatts in Millions)

Type of Prime Mover	Electric Utilities				Non-utility Producers				Total			
	Generation		Capacity		Generation		Capacity		Generation		Capacity	
	Kwh	%	Kw	%	Kwh	%	Kw	%	Kwh	%	Kw	%
Hydro	73,945	26.4	15	23.5	4,959	1.8	1	1.8	78,904	28.2	16	25.3
Steam	152,328	54.5	33	54.1	43,337	15.5	11	17.8	195,665	70.0	44	71.9
Internal Combustion	1,916	0.7	1	1.7	3,040	1.1	1	1.1	4,956	1.8	2	2.8
Total	228,189	81.6	49	79.3	51,336	18.4	13	20.7	279,525	100.0	62	100.0

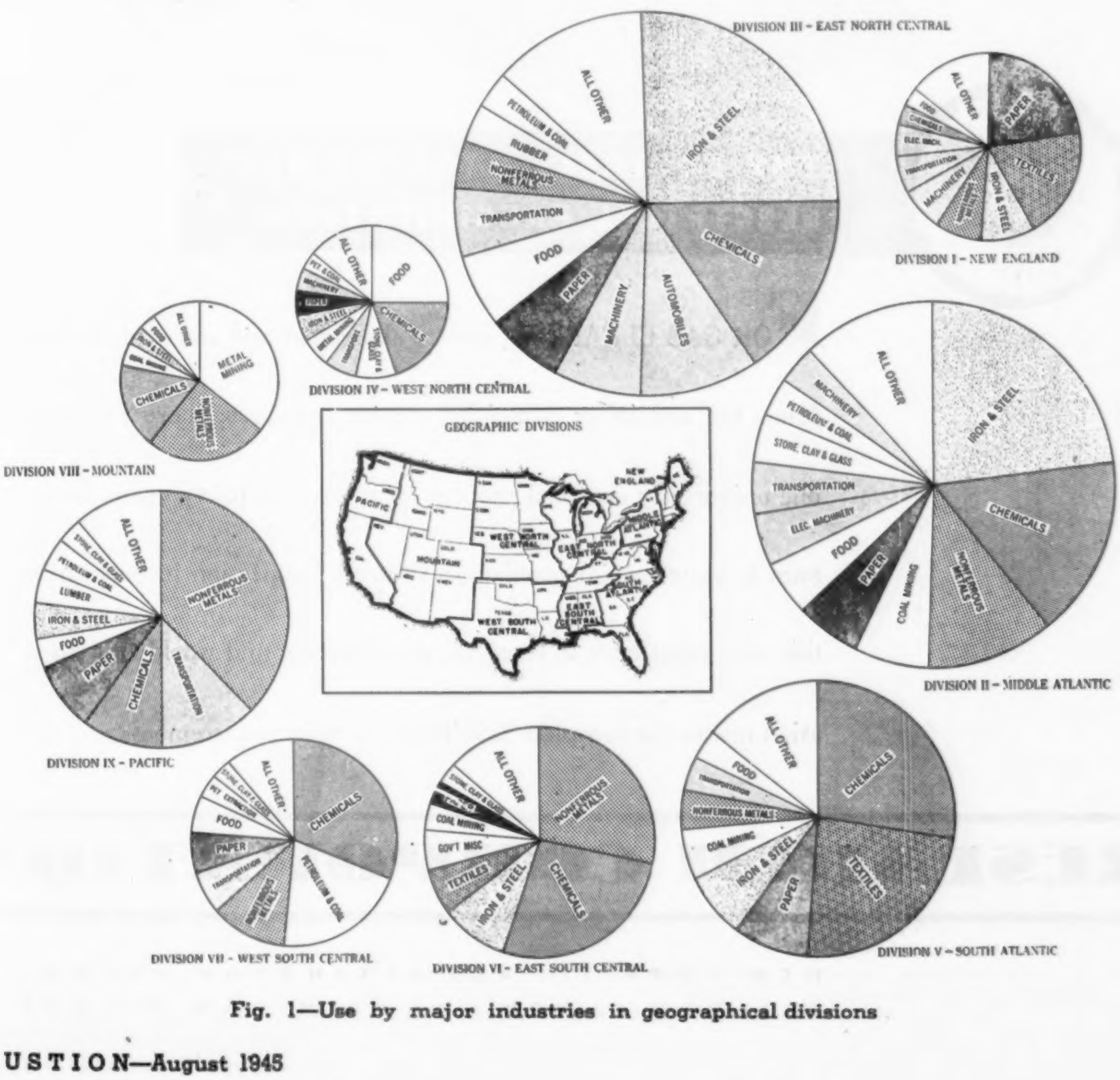


Fig. 1—Use by major industries in geographical divisions


IN INDUSTRY...
IN THE NATION...
ONE recognized standard
IN THE WORLD

New Marine Gas-Turbine Plant Demonstrated

Description of a 2500-hp gas-turbine plant built by the Elliott Company for the U. S. Navy. The unit has an overall efficiency of approximately 29 per cent and weighs 30 lb per horsepower. A number of the design, material and manufacturing problems encountered in meeting the high temperatures involved are recounted.

THE first gas turbine designed for ship propulsion was demonstrated at the plant of the Elliott Company, Jeannette, Pa., on July 25 before a group of engineering editors and press representatives.

Rated at 2500 hp, the unit was produced through the joint efforts of Elliott engineers and the U. S. Navy, Bureau of Ships, and was predicated to some extent upon the Company's experience since 1940 in turning out vast numbers of turbochargers for diesel engines. The turbine plant has an overall efficiency of about 29 per cent, weighs 30 lb per horsepower and occupies a space of approximately $3^1/_2$ cu ft per horsepower, although this last figure is expected to be decreased in subsequent units. At present high-grade fuel oil is burned, but no serious difficulties are anticipated with burning lower grades of oil. Orders are on hand for three additional units, one of which is intended for installation on a cargo ship by the U. S. Maritime Commission. Two of the three units will drive electric generators in order to simplify the problem of reversal and the third will drive a reversible-pitch propeller.

Description of Plant

In describing this unit, **R. A. Riester,** observed that there are many combinations of turbines, compressors, combustion chambers, intercoolers and regenerators that can be employed in a gas-turbine plant. In this case the plant consists of two turbines, two compressors with intercooling, two combustion chambers and a regenerator, as indicated diagrammatically in Fig. 1. The flow of gas begins at the low-pressure compressor *A* which takes in free air and compresses it to 43 psi abs and 300 F. The temperature is then lowered in the intercooler *B*, whereupon the air passes to the high-pressure compressor *C* which raises the pressure to 96 psi abs. The air then passes through the regenerator *D* where a portion of the heat in the exhaust gas from the turbine *H* is recovered before it enters the high-pressure combustion chamber.

In the high-pressure combustion chamber *E* fuel oil is burned directly in the air stream and a temperature of 1230 F is reached at the entrance to the high-pressure turbine *F*. The hot gas is expanded in the turbine to 53 psi abs and thus develops power to drive the low-pressure compressor *A*.

Exhaust from the high-pressure turbine is then elevated in temperature to 1207 F in the low-pressure combustion chamber *G* and passes to the low-pressure turbine *H* which drives the high-pressure compressor. Approximately 5000 hp is developed by the low-pressure turbine, half of which is expended in driving the high-pressure compressor and the other half is available for useful power.

After the exhaust leaves the low-pressure turbine at slightly above atmospheric pressure, it passes to the regenerator *D* where it preheats the compressed fresh air from the high-pressure compressor; after which the exhaust gases pass to the stack at about 400 F. Control is effected by regulating the fuel to the turbine driving the first-stage compressor, since the amount of air entering the system is governed by this compressor.

It will be observed that the two compressors are driven by separate turbines. While this is not essential, it is desirable for a naval plant which operates more than 90 per cent of the time at other than full load; and it is therefore important to have highly efficient part-load performance.

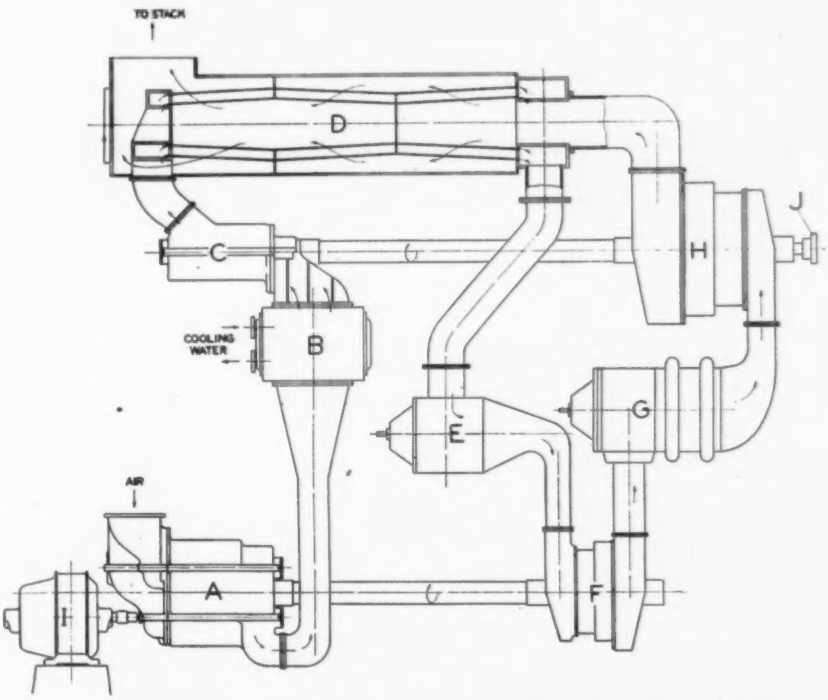


Fig. 1—Diagram of plant showing relation of component parts

An idea of the actual arrangement of the several components of the gas-turbine plant is had from the transparent scale model, Fig. 2.

Heat Supply for Gas Turbines

In explaining why it is necessary to employ such high temperatures with a gas turbine, **M. A. Mayers,** stated that the output of a gas turbine plant is determined by the difference in temperature level between the expansion of the gas in the turbine and the compression of the air in the compressors. If it were possible to have perfectly frictionless compressors and turbines without any loss, the air could be compressed in the compressor and expanded in the turbine and the turbine would just drive the compressor, but there would be no power left over for useful work. However, it would be found that if the temperature of the compressed air were further raised before expanding it, useful work could be got out of the machine.

The actual gas turbine plant operates in this way; but since real machinery has losses, it is necessary to raise the temperature of the air in order to make the machine operate even without delivering useful output. The larger the losses the higher must be the temperature of the compressed air in order to make the machine self-sustaining. The higher the temperature of the compressed air before

expansion, the greater the useful work and the higher the efficiency of the plant. Thus the aim is to operate gas turbines at the highest temperatures possible with available materials. The temperature is raised by burning fuel in the combustion chamber, thus adding heat directly to the working fluid.

However, not all of the temperature rise of the compressed air is obtained by burning fuel in the combustion chamber, as part is obtained from the hot exhaust gases from the low-pressure turbine by recirculation to the regenerator. For best economy it is desirable, when operating at reduced power, to decrease the supply of compressed air rather than to reduce the gas temperature.

Materials to Withstand High Temperatures

One of the major problems in designing a successful gas turbine plant is that of finding suitable materials to withstand operation at the high temperatures required for high thermal efficiency. Not only is the strength of the metal reduced at high temperature, but also creep becomes apparent when exposure to high temperature is prolonged. Fabrication of some of these materials is difficult. Some of these manufacturing problems were reviewed by **J. F. Cunningham, Jr.**

Fig. 3 indicates the materials used and the corresponding temperatures for all parts of the plant.

The nickel torroidal joints in the high-pressure combustion chamber inlet represented an interesting problem. This duct is made of chrome-molybdenum steel to operate at temperatures up to 1000 F. The torroidal joints are spinnings, 0.025 in. thick. If made of chrome-molybdenum steel, they would have been subject to scaling which would be dangerous in that the metal is already of minimum thickness. Austenitic stainless steels have a higher coefficient of expansion than chrome-molybdenum, which would have caused intolerable differential stresses; and ferritic stainless steel cannot be spun successfully. Copper alloys have high coefficients of expansion and very poor high-temperature properties. Nickel is usually a work-hardening material that cannot be spun; but a special grade of nickel was produced in small quantities for this purpose which could be spun.

Castings, though simple and convenient to design, are hard to produce in high-temperature alloys and do not have the high-temperature properties of rolled or forged material of the same analysis. Moreover, because riveted joints depend primarily on tension in the rivet, they could be used only in minor attachments.

Therefore, in general, the only recourse was to use rolled plate and arc welding, and by this method to fabricate many pieces into a single assembly. This

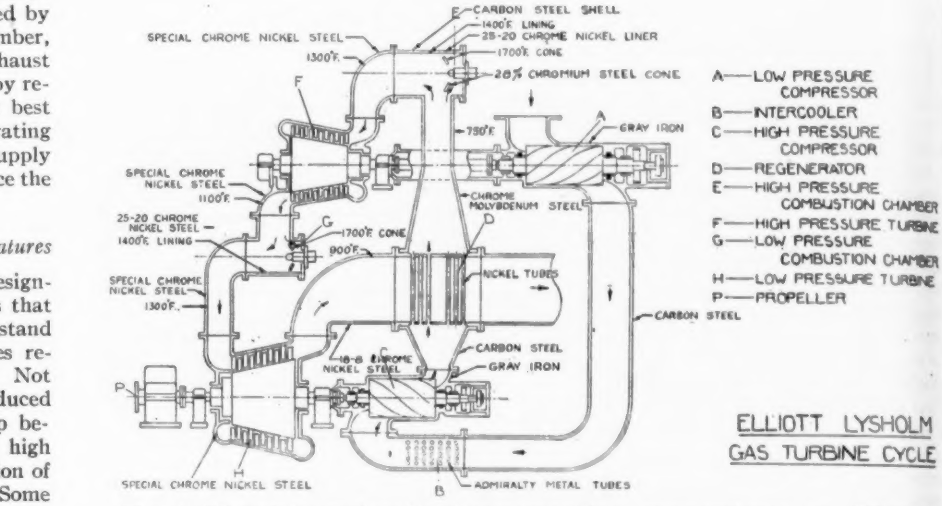


Fig. 3—Materials employed and corresponding temperatures in different parts of plant

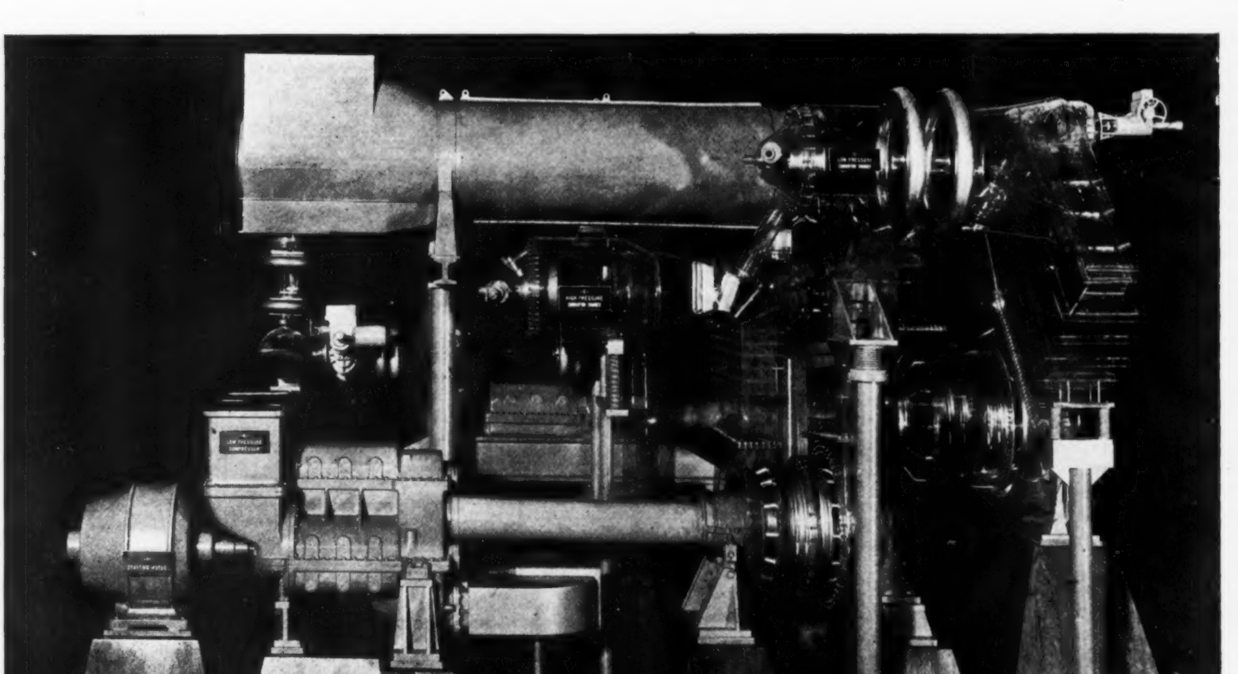


Fig. 2—Transparent model of gas-turbine plant

method was used in all the ductwork and in the combustion chambers. The turbine rotors were assemblies machined from rolled plate and forgings and welded.

The welding also presented some interesting problems. For instance, SAE 4130 chrome-molybdenum steel is of an air-hardening variety and there was danger that when a weld was made the heat would cause an extremely hard, brittle zone adjacent to the weld. This characteristic is more pronounced in heavy pieces than in light. Therefore, it was necessary to check each weld prior to its being made, to set up procedures and to determine whether preheating would be required. Also, the welding of 19–9 WMo material presented an entirely new problem and a special welding electrode had to be developed for this purpose.

In constructing the regenerator, a large number of joints was necessary to transmit the heat from the tubes to the fins. Some idea of the number of joints can be had from the fact that over $8^1/_2$ miles of nickel tubing were required, and the joints had to remain strong at a temperature exceeding 1000 F. After considerable testing, a method was developed for building these regenerators from nickel tubing and sheets by a copper brazing process.

New Type of Compressor Employed

As is well known, the efficient production of power by a gas turbine plant necessitates the compression of large volumes of air economically; that is, upon the efficiency of the compressor, so as to minimize the nonuseful energy. This led to the decision to employ a new form of compressor, developed by Alf Lysholm, a Swedish engineer, in collaboration with Elliott engineers.

As illustrated in Fig. 4, this compressor is simple and rugged. It has only two moving parts and combines the advantages of a reciprocating compressor with those of a strictly rotary type. The two cooperating rotors, which are timed by the ground gears directly mounted on their shafts, are journaled in precision automotive-type bearings and all parts are enclosed in a machined casing which is

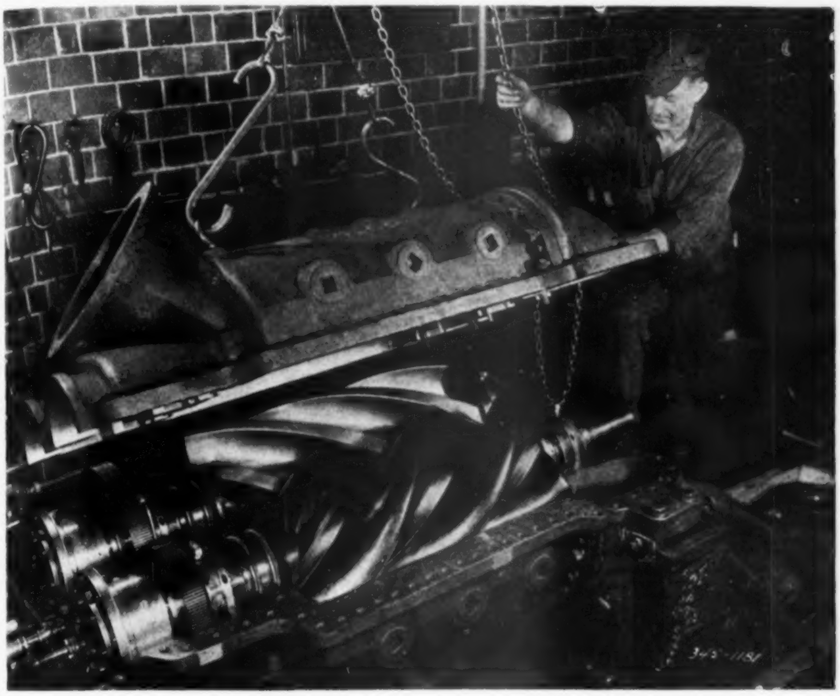


Fig. 4—Lysholm compressor with cover raised

jacketed to insure symmetrical temperature distribution. While running at high speed it takes in successive bites of air which are enclosed, cut off, and compressed by squeezing, and finally forced into the outlet. At both the intake and exhaust the successive bites of air overlap so that a continuous flow is obtained. In other words, it is a positive displacement machine which for each revolution of the shaft takes in and compresses a fixed volume of air independent of the back-pressure imposed. Thus, over a broad range, the operating pressure can be independent of air quantity, hence provide flexibility in the selection of the flow-pressure relationship to suit the turbines.

Since the plant had been designed as a marine propulsion unit for the U. S. Navy, the demonstration run included manipulation of the turbine in accordance with marine requirements.

Commenting upon possible future applications of the gas turbine, **Ronald B. Smith** observed that, without displacing other forms of prime movers, it has certain advantages that should win a wide sphere of influence. It is rapidly assuming an important place in the field of aviation; and in the marine field, by virtue of its light weight, compactness, simplicity and efficient operation over a wide range, it has a promising future. Moreover, he mentioned that several of the major railroads have lately made available development funds for the creation of a coal-burning gas turbine, in which direction the Elliott Company is already experimenting.

Ickes Analyzes the Fuel Situation

THE following statement concerning the present coal outlook and the decision to ship six million tons to Europe was made by Solid Fuels Administrator Ickes before the Senate War Investigating Committee on July 31. From this the gravity of the situation is apparent.

Unless sufficient miners are quickly released from military service so as to increase coal production to an adequate rate, next winter will be the coldest of the war for the people of the United States. This would be true even if we did not send a pound of bituminous coal to Europe.

After taking into account the effects of Germany's defeat on our fuel requirements, but not considering the shipment of the contemplated 6,000,000 tons of bituminous coals to Europe before Jan. 1 next, our soft coal requirements were estimated at approximately 600,000,000 tons for the fuel year which began last April 1. Our requirements for the domestic sizes of anthracite coals were calculated at 55,000,000 tons. These are sound figures based on the most accurate facts which trained coal men and economists could assemble.

On the production side of the ledger, present trends in manpower indicate that the ceiling on soft coal output for this fuel year is 575,000,000 tons. For the domestic sizes of anthracite, it is 43,000,000 tons.

Huge Shortage Indicated

These figures point definitely to a deficit of 37,000,000 tons between what we can produce and what we shall need. Up to this point, we have gotten by without real impairment of industrial activity, despite production deficits, by falling back on the tremendous reserves of soft coal which industry had built up in its stockpiles under the leadership of the Solid Fuels Administration during the early days of the war when we could still produce more than we needed. These stockpiles are now practically depleted and we can draw on them for comparatively little more fuel to tide us over emergencies without the risk of closing down plants.

Already it has been necessary for the Solid Fuels Administration to curtail deliveries of the eastern-mined soft coal, anthracite, and by-product coke to four tons for every five normally consumed by householders and other domestic users. It may be necessary to extend these limitations to other domestic coals. Also, industrial plants face the threat of a serious cut in coal supplies before the winter is over, regardless of whether we ship coal to Europe.

When fuel oil became scarce, early in the war, it was a relatively simple matter to fall back on coal, which was then in ample supply. Our fuel oil supply is still critically short. Now that coal is short, we have no other source of heat and energy to which to look for relief. Wood, and coke, too, are extremely scarce and this adds substantially to the burden imposed on coal.

Turning now to the European fuel situation, the conclusion that we should permit, if possible, the shipment of approximately 6,000,000 tons of bituminous coal to the devastated nations of that continent before next Jan. 1 was not arrived at lightly. I was largely influenced by the urgent and unanimous recommendations of the Department of State, the Office of War Mobilization, the Foreign Economic Administration and the War Production Board. In fact, these agencies advocated sending even more than that. The Army, which is so reluctant to release miners to dig coal, participated in these discussions and agreed that the shipments should be made. It did so, I might add, with full knowledge of our own fuel problem at home.

European Needs Vital

We have been forewarned by competent advisers, who have examined conditions on the ground, that if immediate steps are not taken to increase the coal supply in the liberated nations of Europe to a point that will sustain human life next winter, we must expect rioting, bloodshed and the destruction of nearly all semblance of orderly government. Our interest in preventing such a catastrophe should be obvious to every American. American lives are at stake in the occupied lands where our troops are stationed to preserve order. Upon coal is dependent Europe's chance to build sound, decent governments; to rehabilitate industries so as again to produce enough food, clothing and other goods to sustain life; and to assume her responsibilities for helping to establish a safe and lasting peace.

It is hard to conceive how the coal situation in Europe today could be worse. Factories producing critical food and clothing have been closed down in order to provide a little additional fuel for cooking and hot water. Food rots in the fields for lack of coal to transport and process it. The Dutch, for example, would have to increase coal production 40 per cent to give each family four-fifths of a ton for an entire year's needs. These heroic people lack fuel to pump out the floods turned loose on fertile fields when the dykes were cut, and manufacturing and transportation are practically at a standstill for lack of coal. There is no fuel to make fertilizer, and so crops have been planted without it, with the result that the expected yield will be but a fraction of normal. Most of the trees of Holland have been cut down, and paving blocks ripped up from the streets to provide a little heat. Hot meals in Europe are but a happy memory, and baths are in the same category. The story is the same throughout the devastated areas—the only difference is one of degree. In general, the liberated peoples are faring worse for fuel than under German occupation. It would be too cruel to throw off the brutal Nazi rule and impose in its stead an even more heartless deficiency of coal.

The destruction and disorganization of Europe's industries are so complete that it is now utterly impossible to increase coal production in time to meet this problem next winter.

A minimum of 25,000,000 tons in excess of the amount now in sight from European mines, and in addition to our contemplated 6,000,000 tons, is necessary to bring next winter's coal supplies in Europe's devastated areas up to the point where law and order can be preserved. This would not be enough to make their homes comfortable, but only barely sufficient to prevent unbearable suffering.

At the present time, France, always an importer of coal, is producing at 65 per cent of the prewar normal rate. In Germany, the principal source of fuel on continental Europe, production is 10 per cent; in Belgium, output is 50 per cent; and in the Netherlands, it is 33 per cent. Because of the lack of transportation, the mines of Poland can help but little, although they are now offering, at great sacrifice, about 100,000 tons per month for export to the other devastated areas.

Germany Not to Benefit

Not a pound of the 6,000,000 tons contemplated for Europe would be for the people of Germany, who must look to their own mines for whatever measure of heat and energy the commanders of the occupied zones feel that they should have, after providing coal for the devastated areas. But we do have to consider requests for fuel from the so-called neutral nations of Europe. We intend to examine these requests with the utmost caution since some of them come from countries that have grown fat from the profits of their synthetic neutrality.

The contemplated American shipments include some coal for our own military forces, and to replace fuel which the Army is now commandeering out of Europe's pitifully small supply.

In June of this year, Deputy Solid Fuels Administrator C. J. Potter headed the Potter-Hyndley Mission to Northwest Europe, which thoroughly explored the coal situation there. This mission determined that if proper steps were to be taken quickly the mines in Western Germany could be rehabilitated sufficiently to provide the additional coal needed in the devastated areas. It found that the restoration of production was largely a matter of organizing the resources already available there for producing and transporting coal, and for getting the job done. Unfortunately, the recommendations were not placed in effect at that time. Germany's industrial organization was in such an inconceivable mess that it created most difficult problems for the military commanders to meet.

Although efforts are being made to restore German production, it is now too late to count on that source alone to prevent anarchy next winter. Furthermore, Britain cannot help. Her expected production will be far short of her own needs. Coal now is being produced in the United Kingdom at a rate of 180,000,000 tons per year, as compared with 230,000,000 tons in 1939. In the southern part of Great Britain, each family's ration of coal is but 2.3 tons for a year, and in the north it is a mere ton more, regardless of the size of the house. Nor can Northwestern Europe look to Africa, India or any other source

except America, for increased shipments of fuel.

It is obvious that the 6,000,000 tons which we contemplate shipping from America between now and January will not prevent unbearable deprivation and intense suffering on the part of scores of thousands of Europeans next winter. But it will help immensely. In fact, I believe that it may spell the difference between orderly government and anarchy.

On April 25, I concurred with the Acting Secretary of State, the Foreign Economics Administrator, and the Chairman of the War Production Board, in a recommendation that approximately 7,500,000 tons of American coal be exported to the liberated areas of Europe. At that time, it appeared that we might provide the coal without harmful effects at home. However, the continuing decline in mine manpower, production losses due to strikes, and the failure to obtain the release of miners from military service made it obvious that American production could not be increased, nor could our consumption be decreased sufficiently to ship the coal without injurious effects at home. Common sense and desire then to avoid risk of prolonging the war with Japan for lack of fuel prompted me to withhold action on these initial recommendations, and, meanwhile, to leave no stone unturned in trying to increase our production. As I have always maintained, coal cannot be produced without adequate manpower, in short without well-fed, well-clothed and willing miners.

We have long been working hard to increase production by an extension of the working time, by insisting upon the deferment of miners, by stimulating the recruitment of additional men, and by reducing production losses because of seasonal operations and absenteeism, and other similar actions. Also, we have been trying to reduce requirements by promoting the conservation of coal, and have now intensified these activities to the fullest extent of our resources.

When the increasing gravity of the fuel situation and Europe's plight became still more apparent, we redoubled our efforts wherever possible. During the wage controversy, we moved expeditiously to take the mines into government possession wherever strikes threatened impairment of the fuel supply. Everything within my power was done to speed a satisfactory settlement of the wage disputes, and mines were quickly returned to private possession when the danger of work stoppages had passed so that normal operating conditions could be restored. Unfortunately, *many million tons of production were lost because of these strikes.*

Wildcat Strikes Reducing Output

Since the wage settlements, there have also been many so-called "wildcat" strikes. During this month, these cost us more than 1,160,000 tons of bituminous coal and in June the total was nearly 1,000,000 tons. The miners attributed some of these strikes to lack of meat and fats and we have succeeded in persuading the Office of Price Administration to allow them more red points. We have also done everything possible to see that more meat is provided in mining communities. Such controversies could and should be adjusted without strikes, and I am now bending every effort to end these sporadic work stoppages at this critical time.

As I have said, the only answer to our production problem is more miners. There has been a steady deterioration of mine labor forces since 1941, when the average number of mine employees totaled over 545,000. Preliminary statistics for 1944 showed the average number to be 461,000, and in 1945, we expect to sustain a net loss of 19,000 more men. Besides, production efficiency is necessarily impaired by the fact that the average age of miners today is from 48 to 50 years. The young and vigorous miners are in the Armed Services.

I have consistently pleaded the necessity of maintaining our mine labor forces so as to save us from the error made by Britain. The British permitted their miners to be drained off into military service early in the war, and have suffered the dire consequences of acute impairment of their coal supply. Measures to draft men into the mines from civilian life have failed to correct this mistake. This should have forewarned us, but it did not. I think that it is fair to say that England's coal trouble today stems from the failure in that country to appreciate the imperative necessity of producing coal to support the war. It is a truism that coal is the base upon which the production and transportation of munitions of war depend.

Release of Men Imperative

And now, we are at the point where our only hope of solving our own production is to release men promptly from military service and if we cannot solve our own problem, we cannot continue to ship coal to Europe in any amount. When I went on record in favor of shipping coal to the devastated countries of Europe, I made it clear that unless miners were released to produce more coal it would be necessary to discontinue shipments, unfortunate as would be the results of such a step.

As I have said we consistently opposed the policy of taking men out of the coal mines to put them into the armed forces, the successful outcome of which depended upon coal. The Army successfully resisted our urgent representations. Later we began discussing the production of coal with General Clay, who at that time was Deputy Director of the Office of War Mobilization and Reconversion. On May 31, the Secretary of War was formally apprised of the fuel situation by me. I appealed in writing for the release of men. My request was reiterated more than once. The most recent appeal for the release of 30,000 mine workers has been frowned upon. I sincerely believe that these men can accomplish more for the Army in lessening the chance of civil disturbances in Europe and in maintaining industrial production at home than if they remained in the Army, especially since the Army is reducing its own manpower. It goes without saying that, unless we get miners quickly, 30,000 will not be enough. We

shall need more miners in proportion to the delay in releasing them.

I understand that the Army has made arrangements to transfer 2600 German miners from American prison camps back to German mines. Unfortunately, such a transfer will not provide anywhere near an adequate answer to the problem of coal for Europe. The transfer will take time and in any event the assistance that these German miners will provide will scarcely be felt amid the demoralization of the German mining industry. Moreover, their assistance will not be effective unless they are properly fed and clothed. The Germans realized before we did that such heavy work as prevails in the mines cannot be sustained without sufficient and proper food.

Ultimately Europe's coal problem must be solved on the Continent of Europe, but this cannot be done overnight, and until it can be done, our Allies need our help. It is obvious that American coal must be sent across the Atlantic. Several days ago it became equally obvious that such shipments must be started without delay if this help is to reach Europe in time. I reached the conclusion that shipments should be permitted to start notwithstanding the Army's reluctance to release miners.

If we are to send coal to Europe without prompt release of necessary miners, we must realize that this will cause an even greater emergency at home than is indicated by the 37,000,000-ton deficit with which we already are confronted. In such an event, I do not see how we can avoid curtailing supplies to industry which would mean a partial or complete shutdown of some vital plants and perhaps prolong the war with Japan. Even a partial industrial shutdown means unemployment. Our ability to provide every coal consumer with his 80 per cent quota would also be in jeopardy. Thus we would be in the anomalous position of disrupting our domestic economy, of encouraging disorder in Europe and of providing for our homes less heat than is required, not because we do not have plenty of coal in this country, not because we haven't more than enough miners to mine the coal, but simply because we keep out of the mines the men who can produce the coal.

New Patent Office Service

The U. S. Patent Office has put in operation a new service to industry and inventors. The purpose of the service is to bring to the attention of the nation patented inventions under which the owners are willing to grant licenses on reasonable terms. It is believed that such information will lead to greater employment opportunities in the reconversion period, as well as permit industry to become acquainted with what is being done in various fields.

To accomplish the purposes set out above, a "Register of Patents Available for Licensing" is now being established, and will be maintained in the Patent Office. Patents recorded on this register will be available to the public for inspection in Washington, D. C. Lists of such patents will be published in the Official Gazette of the Patent Office.

Army Training for Power Plant Service

In rehearsal for roles they were expected to play in Uncle Sam's program of building bases for carrying the war to Japan, members of the Army Engineers Corps have been undergoing intensive study and training at the East Pittsburgh, Pa., works of the Westinghouse Electric Corporation.

These youthful service engineers are acquiring the "know-how" to install, operate and maintain electric generators, transformers and switchgear destined to bring light and power to military installations where no previous power existed in the Philippines, Iwo Jima and other far-off Pacific battlegrounds.

The fifty-three military students, constituting the first of many groups which the Army had planned to send into industrial plants for specialized instruction, hail from Fort Belvoir, Virginia. Most of them possess some engineering background and all have been chosen because of particular aptitude in that field. The course includes classroom lectures and discussions, demonstrations in shop and laboratory, and the actual handling and operating of power equipment.

Not only must the men be thoroughly familiar with new power plant installations, but they have to be able to rebuild or revive electric stations that may have been only partially destroyed or damaged by fire, bomb or shell. For this reason they are trained in many expedients necessary to set up generators in parallel with existing systems, and in the many complicated techniques of wiring, relays, switchboards, control panels and feeder panels, meters, circuit-breakers, voltage regulation and load division.

Electric Companies Announce Stand on Federal Power Projects

One hundred and sixty-seven of the nation's electric light and power companies, representing a large part of the business-managed electric industry, in a joint statement have made known their position with regard to proposed river developments by the United States Government. These developments, providing for the creation of the Missouri Valley Authority and other projects similar to TVA, as well as the completion of several already in operation, entail an estimated initial expenditure in excess of $3,850,000,000.

Four specific points are made by the electric companies in defining their attitude toward these government undertakings; these are:

1. When a dam is proposed, all of its purposes should be clearly defined in the legislation—flood control, navigation, irrigation or power. And just as clearly, the benefit to the people affected should justify the cost.

2. If power is produced at government-built dams, it should be sold to existing power systems, without special privilege or discrimination. This will save the expensive duplication of transmission facilities, help to coordinate the entire power supply of each region, and assure its widest possible use at the lowest practical rates.

3. Any savings made possible by this plan should be passed along to the users of electricity, under regulation by State Commissions or other properly constituted regulatory bodies. This will assure all the benefits of river development and hydro-power without the added expense of government going into business and competing with its own citizens.

4. Government in any business endangers all business. Government in business escapes many normal business obligations, enjoys free mail, pays no federal taxes, and few, if any, other taxes, little or no interest. If government can sell electricity on this basis, it can sell shoes, groceries, automobiles, or anything else the same way. Government may properly regulate business in the public interest but should not operate business. It should not play in the game for which it makes the rules. In other words, government should not try to be umpire and pitcher at the same time.

The companies sponsoring the statement are members of a group participating in a campaign to keep the public and their own investors informed regarding problems affecting the industry. C. Hamilton Moses, president of the Arkansas Power and Light Company, one of these companies, made the following comment regarding the announcement:

"This announcement is designed to clarify the position of the electric companies regarding river developments along the pattern of TVA. The companies have been wrongfully charged with attempting to block such valley developments.

"This is an injustice to the electric companies. We do not oppose any government project of this kind provided it is economically sound. What does concern us is the threat of annihilation of the business-managed electric industry by the use of taxpayers' money to subsidize government power plants unfairly competing with the American business man."

MVA Bill Reported Unfavorably

The much-discussed bill pending before Congress to create a Missouri Valley Authority, to establish and administer a broad program of flood control, navigation control and power development for the entire Missouri Valley region embracing ten states, was recently reported unfavorably by the Senate Commerce Committee. In doing so, the Committee pointed out that flood control involves a Mississippi basin problem of which the Missouri River is only a tributary and that the agency best qualified to handle both control and navigation is the U. S. Army Engineer Corps which for more than a hundred years has been charged with such duties. The Committee was of the opinion that existing legislation, as provided in the Flood Control Act of December 1944 was ample to cover a coordinated plan of flood control, irrigation, hydroelectric development and other relative purposes in the Missouri basin, by the Army Engineers and the Interior Department, without setting up an independent agency for such purposes.

The Bill must also be considered by the Senate Committees on Agriculture and Irrigation and Reclamation.

A.I.E.E. Elects Officers

Dr. William E. Wickenden, President, Case School of Applied Science, Cleveland, Ohio, was elected president of the American Institute of Electrical Engineers for the year beginning August 1, 1945, as announced at the annual meeting of the Institute held earlier in New York. The other officers elected were: Vice Presidents E. S. Fields, Cincinnati, Ohio; H. B. Wolf, Charlotte, N. C.; L. M. Robertson, Denver, Colo.; F. F. Evenson, San Diego, Calif.; F. L. Lawton, Montreal, Canada. Directors J. M. Flanigen, Atlanta, Ga.; J. R. North, Jackson, Mich.; Walter C. Smith, San Francisco, Calif. National Treasurer W. I. Slichter, New York, N. Y. (re-elected).

The annual report of the Board of Directors, presented at the meeting, showed a total membership on April 30, 1945, of 23,072.

Personnel Changes Among Manufacturers

The following executive changes have been announced by the Peabody Engineering Corporation, New York:

David P. Graham, assistant to the president, has been made second vice president and a member of the board of directors. **Charles B. Hill** continues as first vice president. **Clarence A. Snider,** formerly secretary-treasurer, is now treasurer and **H. Victor Crawford** was elected secretary. These officers comprise the company's board of directors.

George C. Siefert, for some years past manager of the Proposition Department of Combustion Engineering Company, New York, has been appointed Mexican representative of the Company. He will be located at Equipos Mecanicos, S. A., 157 Paseo Reforma, Mexico City, Mexico.

The Wm. Powell Company, Cincinnati, has appointed **Allen B. Stiles** as manager of its Philadelphia and Baltimore territory with offices at 1520 Locust Street, Philadelphia.

Plibrico Jointless Firebrick Company, Chicago, announces the following appointments:

W. R. Griffith as manager of the Plibrico Sales & Service Co., Akron, O., succeeding **Carl V. Faber,** retired. **Carl C. Grimes, Jr.,** as manager at Des Moines, Ia., and **John W. Wright** as manager at Fort Wayne, Ind., succeeding **Frederic L. Ruoff** who has been transferred to Chicago headquarters as manager of the construction department.

After three years with the Army Air Forces Training Command, **Captain Don Allshouse** has been placed on inactive status and has rejoined Northern Equipment Company, Erie, Pa., as Advertising Manager.

The Bird-Archer Company announces the retirement of **R. B. Zane,** Kalamazoo, as sales engineer for the Michigan and Northern Indiana territory. Chemical engineering services will be carried on in this area by **Sylven E. Lawson** of Detroit under the direction of **Edward A. Lowenthal,** Western Manager, Chicago.

Fred W. Deutsch is now associated with Builders-Providence (Division of Builders Iron Foundry), Providence, R. I., as Assistant Sales Manager.

REVIEW OF NEW BOOKS

Any of the books here reviewed may be secured through Combustion Publishing Company, Inc., 200 Madison Ave., N. Y.

Thermodynamic Properties of Air

By Joseph H. Keenan and Joseph Kaye

This book, whose senior author is well known for his textbook on thermodynamics and as co-author of the Keenan & Keys Steam Tables, was brought out to meet the need for working tables on properties of air in connection with gas turbine studies, as well as in the solution of problems in regenerative heating and the expansion of air from states of high temperature. Included are values for viscosity, thermal conductivity conversion factors and tables and typical examples.

There are 73 pages, $7\frac{1}{2} \times 10$ in., bound in cloth; price, $2.25.

Piping Handbook, 4th Edition

By Sabin Crocker

This Piping Handbook shows to what extent piping has become a necessary science. The first 860 pages are mainly devoted to an exposition of the principles underlying the performance and structural design of pipes in general, while the remainder of the book covers in detail various piping systems such as were developed for power stations, hydraulic works, etc.

The laws governing the flow of fluids, such as gases, air, water, steam and oil, and their properties are presented and discussed at length. Unfortunately, the variety of experimental data on friction factors, published in the last twenty years and the lack of proper correlation inevitably lead to a mass of unrelated material difficult to compile and limited in each application. The author is not to be blamed for this, however, as it is due to the lack of a unified experimental method among individualistic investigators.

Following the laws of fluid dynamics is a brief, but valuable, chapter on the metallurgy of pipes and a complete collection of data on pipe fittings as they are now standardized by the various interested branches of industry. A duplication of standard designs is again apparent, to the bedevilment of the engineer who must reach a quick decision.

Of necessity the chapter on heat insulation is short, but the information will enable the designer to solve a large percentage of his pipe-insulation problems.

Stress analysis of piping is treated in part graphically. The discussion has been somewhat expanded when compared to earlier editions of the book, but solution charts have been added which simplify the method considerably.

Mr. Crocker is to be commended for enlarging on the practical application of piping by the addition of chapters on refrigeration and gas piping, corrosion, and hydraulic power transmission piping. The present edition is much more comprehensive than the 1930 edition as may be seen by the number of pages which have increased from 763 to 1376 and the list of contributors which went up from 5 in 1930 to 41 in 1945.

The price is $7.

Physical and Chemical Properties of Pennsylvania Anthracite

Issued by The Anthracite Industries, Inc.
101 Park Avenue, New York 17, N. Y.

This booklet of 25 pages contains much information on the physical and chemical properties of Pennsylvania Anthracite such as will be found useful as a reference by engineers and architects. Included are the heating valves and composition of various coals; typical composition and approved specifications of Pennsylvania anthracite; its physical properties; analysis of volatile matter of coal from various fields; chemical analyses and softening temperature of the ash; size range, weight and volume; angles of repose for storage; draft required at different combustion rates when burning various sizes of anthracite; and air required for complete combustion; together with definitions of terms commonly employed.

Many of the data represent summations of research studies.

Fuel Conservation in Hospitals

This 62-page booklet, issued by the Council of Hospital Planning and Plant Operation of the American Hospital Association, has been prepared both as a permanent guide to improvement in the operation of hospital steam and power plants and to cope with the present and probable future fuel situation. Chapters are included on the selection, purchase and storage of fuel; firing methods and combustion; steam production, including feedwater treatment; and steam consumption, including distribution and its use for power, heating, laundry service, etc.

The treatment is necessarily sketchy in a text of this length, but is practical and covers the essentials within the scope of the average hospital plant. Illustrations and charts are included, as well as considerable data that should be helpful toward efficient operation and administrative control. It is an answer to the realization that the power plant represents the one department most susceptible to improvement in economy in most hospitals.

The price of this booklet is 75 cents with paper cover and $1.50 if bound in cloth.

Standards List

A new list of all American Standards and War Standards approved to date has just been published by the American Standards Association.

There are approximately 800 standards listed in the booklet, covering specifications for materials, methods of tests, dimensions, definitions of technical terms, procedures, etc., in the electrical, mechanical, building, transportation, textile, and other fields. For ready reference, the standards are listed alphabetically as well as by engineering fields. There is also a separate list of the War Standards —jobs carried through since Pearl Harbor at the specific request of Army, Navy, or industrial groups.

The complete list of American Standards should serve as valuable reference material to engineers, manufacturers, purchasing agents, etc. It will be sent free of charge to anyone interested in this work. Requests should be addressed to the American Standards Association, 70 East 45th Street, New York 17, N. Y.

We have received so many requests for extra copies of the July COMBUSTION containing the article by Mr. Van Brunt on "Tube Failures in Water-Tube Boilers" that we have ordered several hundred reprints. Copies will be available gratis upon request as long as the supply lasts.

No Annual Meeting of American Welding Society

The Annual Meeting of the American Welding Society, usually held during October of each year, will not be held this year because of troop travel and hotel conditions. Such meetings are usually attended by several thousand welding engineers and designers. Instead, there will be a meeting of the national officers, board of directors, and committee chairman in New York at the Hotel Pennsylvania on October 18 to deal with matters which require official action and cannot be delayed. This group will also present the Society prizes, medals and other awards which have been given in past years at the opening sessions to those who have made outstanding contributions in the advancement of welding.

Although the annual meeting has been cancelled, the Program Committee has arranged for the presentation of the papers prepared for it in the *Welding Journal* which will also carry discussions of the papers. In this way it is expected that a part of the value of the usual member meeting can be saved for the entire membership of the Society.

This action was taken before the announcement by the ODT, following peace negotiations with Japan, to the effect that meetings involving an attendance of up to 150 out-of-town people would be permitted.

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request.

De Laval Products

The De Laval Steam Turbine Company has issued a new 24-page catalog (No. 1181) devoted to the complete line of Steam Turbines, Helical Gears, Centrifugal Pumps, Centrifugal Compressors, Worm Gear Speed Reducers, and IMO Oil Pumps made by that company. In addition to briefly describing the equipment, this catalog tells something of the more noteworthy achievements of the company, particularly in the development of high-pressure marine propulsion units and in the introduction of centrifugal pumps for water works service.

Dynamometers

W. C. Dillon & Company has published a 20-page illustrated booklet presenting the story of the traction type dynamometer and its industrial uses in simplifying testing and weighing procedures. Dillon dynamometers are available for nine different capacities ranging from 500 lb to 20,000 lb.

Feed Water Regulators

An 8-page Bulletin, No. 83-C, entitled "Bailey Thermo-Hydraulic Feed Water Regulators" has been issued by Bailey Meter Company. It describes and illustrates improved designs of thermo-hydraulic generators and bellows operated feed water regulator valves, suitable for feed lines ranging in size from $^3/_4$ in. to 6 in. inclusive. A full page colored schematic illustration demonstrates the thermo-hydraulic principle which is entirely self-contained requiring no outside source of power.

Heat Exchangers

A 4-page folder issued by The Brownell Company covers its line of hot water generators, closed heat exchangers and converters, and open heat exchangers. Heating capacities of regular models range from 60 to 4400 gallons per hour; storage capacities from 25 to 1904 gallons.

Pennsylvania Anthracite

"The Physical and Chemical Properties of Pennsylvania Anthracite" is the title of a 25-page typescript booklet just issued by The Anthracite Industries, Inc. The material in this booklet represents a technical digest of a number of research studies and standards, and comprises a very useful collection of data for those interested in this particular fuel.

Government-Owned Surplus Property

"How to Do Business with RFC" is the title of a 32-page booklet published by the Reconstruction Finance Corporation—the agency designated by the Surplus Property Board for the disposal of surplus aircraft, industrial plants, producers' and capital goods. The booklet lists nearly 3000 items of Government-owned surplus property and also lists 31 RFC agencies designated to handle these properties and the regions they serve.

Numerous fuels are listed under Coal and Related Commodities, and, under Miscellaneous Industrial Equipment, such items as—land power boilers, combustion controls, compressors, steam condensers, power distribution equipment, power transmission equipment and valves. Instruments include—draft gages, electric power instruments, power factor meters, pressure gages and thermocouples. Machinery includes—internal-combustion and steam engines, gas-, mercury-, steam- and water turbines, turbo-blowers and pumps. Buyers interested in acquiring such property are advised to contact the local RFC Agency.

Magnetic Pulleys

A new 32-page catalog describing electromagnetic pulleys and pulley type separators has been issued by the Dings Magnetic Separator Company. This well-illustrated catalog describes in detail uses of magnetic pulleys in various industries, including coal preparation plants and power plants; tells how to select a magnetic pulley; and includes tables, capacities, dimensions, etc. Specifications of Dings air-cooled magnetic pulleys are fully covered and installation photographs are liberally used.

Theory of the Rotameter

Fischer & Porter has just published a new 24-page edition of their "Theory of the Rotameter." It covers the History and Technical Development of the Area-Type Flow Meters, and describes how their patented Ultra-Stabl-vis Rotameter overcomes the effects of viscosity and density in flow rate measurement. The simplicity of the rotameter is compared to "head-type" meter. Rotameter capacities and correction factors for liquids, gases and vapors are also covered. Technical and engineering data together with many diagrams and illustrations are used to stress the advantages of the rotameter over other flow rate meters.

BOOKS

1—How to Read Electrical Blueprints

By Gilbert M. Haine and Carl N. Dunlap

318 pages $5\frac{1}{2} \times 8\frac{1}{4}$ Price $3.00

The electrical industry has many branches and, because of the diversified nature of the work performed and the equipment used, each branch uses a type of blueprint and certain symbols designed to meet its own particular needs. For this reason, and to avoid confusion in the mind of the reader, the text of this book is divided in sections, eight of which deal with different branches of the electrical industry.

Following a brief section on the making of blueprints and the principles involved in laying out a drawing, the reader is introduced to the subject—How to read architectural blueprints; and in the sections that follow: How to read: diagrams for bell and signal wiring; house wiring blueprints; administration building blueprints; automobile wiring diagrams; diagrams of generators and motors; symbols for control diagrams; motor control diagrams; and power station blueprints. Each section is supplemented with an informative list of questions and answers and a set of "quiz" questions designed to test the reader's knowledge of the subject discussed. The book is admirably illustrated with many line cuts and halftones and, where symbols are presented, each symbol is accompanied by a pictorial sketch of the object or equipment indicated. The book also contains a comprehensive 12-page index and a set of nine instructive blueprints in a back cover pocket.

2—Methods of Advanced Calculus

By Philip Franklin

486 pages $5\frac{1}{4} \times 8\frac{1}{4}$ Price $4.50

Methods of Advanced Calculus covers all the material which has become associated with a course in Advanced Calculus. Its difference from the usual treatise in the subject is to be found in the treatment. The applications of the mathematics are stressed rather than the rigorous proofs of the analyses.

Professor Franklin of Massachusetts Institute of Technology has written the text well, has inserted all the steps in the reasoning and has made constant references to previous well-numbered equations. The all too prevalent use of the expressions "it is evident—it can be easily shown—the student can verify" are absent in this work.

Each chapter has a list of references, and a complete bibliography appears at the end of the book. There are numerous problems at the end of each chapter, as well as a list of answers. The author has provided hints for the more difficult problems. Wherever possible, he has chosen problems from physics rather than from abstract mathematics.

In general, the text represents a departure from the usual in that the author has given consideration to the reader by saving the latter many weary hours of puzzling to provide details. *Methods of Advanced Calculus* will be a handy reference for the practicing physicist.

3—Centrifugal Pumps and Blowers

By Austin H. Church

308 pages $5\frac{1}{2} \times 8\frac{3}{8}$ Price $4.50

The use of centrifugal pumps and blowers is axiomatic in almost every industry, yet the literature on this subject has been confined chiefly to technical papers and manufacturers' bulletins. For this reason the author, who is Associate Professor of Machine Design at New York University, has sought to provide a textbook which will serve as a reference work for young graduate engineers who have to deal with this type of equipment.

"*Centrifugal Pumps and Blowers*" covers the basic principles of design, construction and application along the lines of present-day practice. It does not attempt to develop new theories nor go into advanced problems, but references are given to many recent papers for more complete or advanced information. The text of the book is lucid and further clarified by numerous examples and excellent illustrations. Problems are given at the end of each chapter by which the reader may test his grasp of the subject matter.

4—A.S.T.M. Standards on Coal and Coke

132 pages 6×9 Price $1.50

The September 1944 edition of the compilation of A.S.T.M. Standards on Coal and Coke includes five specifications, twenty-four methods of testing and evaluation and six definitions. A major portion of the standards relates to coal, with standard methods covering sampling and analysis, fineness (powdered coal), grindability, etc.; for coke, tests include drop shatter, sieve analysis, etc. Specifications include widely used standards covering classification of coals by rank and by grade, sieves for testing purposes, and requirements on gas and coking coals.

As in many materials fields, standard definitions are extremely important, and through the work of A.S.T.M. Committee D-5 on Coal and Coke which sponsors the publication, definitions have been developed on terms relating to coal and coke, gross calorific value and net calorific value of fuels, and commercial varieties of bituminous and sub-bituminous coals. A proposed test not yet officially promulgated covers determination of agglutinating value.

5—Mechanical Engineers' Handbook

(Fourth Edition)

By Lionel S. Marks

2274 pages 5×7 Price $7.00

Mechanical engineers have welcomed the new 1941 Edition of this standard handbook as eleven years had elapsed since the appearance of the previous edition and in the interim far-reaching advances had been made in many branches of mechanical engineering. The present volume represents the work of more than 90 contributors, each a specialist in the particular subjects covered, and many of the chapters have been completely rewritten, only basic material having been retained from the previous edition.

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